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A German Electric-Omnibus Trolley Line.

By J. B. VAN BRUSSEL.*

Two rail-less electric omnibus lines (Köhler's designs) have recently been opened in Bremen, Germany, and present many interesting features, a few of which the writer has set forth below. Both lines are about two miles long; the distance is covered in twelve minutes, with a maximum speed of 15.5 mi. per hr.

The cars (Fig. 1) are of the ordinary motor-'bus type with inside seats only. The overall length is 21 ft., height 10½ ft., and width 7 ft. The wheel base is 13 ft. There is seating accommodation for 20 passengers, and the car weighs 3.2 tons when empty and 4.7 tons when full. The electrical equipment of the cars consists of a single direct-current series-wound motor set axially along the longitudinal center line of the car and geared to the back axle. It has a normal rating of 18-HP., but may be operated up to a maximum of 35-HP., at 650 r.p.m.

The controller is of the ordinary drum type with magnetic blowout, and has five running steps and two braking ones. It is interlocked with the two foot brakes in such a way that, putting either of these on automatically cuts off the supply of current and keeps it off until the brake has been released and the controller has been turned back to the starting position. Some of the necessary speed variation is effected by coupling the motor field coils in parallel and in series, and the rest by series resistance in the circuit.

One of the most interesting points about these lines is the method adopted for collecting the current from the overhead wires. The two wires are arranged with the negative vertically over the positive, instead of side by side. This gives a simple overhead construction of good general appearance. As only one pair of wires is provided for cars traveling in both directions, 'buses meeting one another on the road have, consequently, to stop and interchange their collectors. But this involves merely opening a plug connection and causes a delay of only from 12 to 15 seconds. The overhead lines are of grooved wire 63 sq. mm. in cross-section area, and are set 11 ins. apart vertically. They are suspended at intervals of from 88 to 98 ft., with additional distance pieces at about 30-ft. intervals. Fig. 3 shows one of the suspensions with the collector. The following description of this construction applies also to Fig. 4: Insulated bolts carry the clamps *x* for the wire *i*, and the whole is supported in the C-shaped forging, which is provided with three lugs for the suspension wires. These wires are attached to poles through insulators so that the usual double insulation is provided. The negative wire is earthed every 1,000 meters, and, being the upper wire, it forms a certain protection for any broken telephone wires which may fall across the line. The positive line is provided with lightning arresters at 1,000-meter intervals.

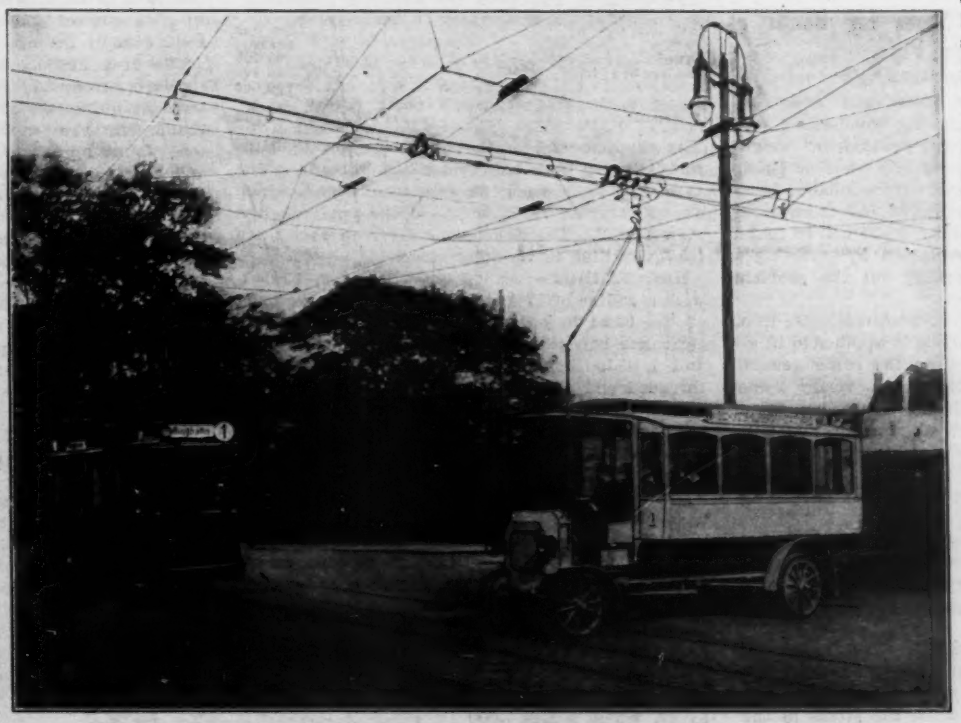


FIG. 1. A BREMEN ELECTRIC OMNIBUS LINE.

The collector for this work must be light and yet very flexible to side pulls, so as to avoid straining the wires unduly when the car has to move from side to side of the road to pass other vehicles. Also the connection to the car must be very flexible and must adjust its length automatically to meet the varying conditions. To meet these demands, the design shown was selected. The collector itself is a combination of over-running trolley and under-running bow. The two trolley wheels at the top are 12 ins. apart, and are carried on a C-shaped arm which also carries the aluminum bow collectors for the lower wire, the upper and lower carriages being insulated from one another at *a* and *b*. The central carrier *e* has two 11-in. hinged arms attached to it which carry the two aluminum bows *g* at their ends. The springs *h* exert a pressure of about 3½ lbs. against the wire, and they allow the bows a limited upward and downward motion of 6 ins. The whole collector is free to move a considerable distance from side to side without danger of damage. This motion not only prevents side strain on the lower wire, but also enables the aluminum bows to wear uniformly all over instead of in grooves.

The weight of this collector is 12 lbs. In order to ensure smooth running and freedom from jerkiness, the collector is connected to the cable from the car through a pair of 2-ft. hinged steel tubes *k*. The end of one tube *m* is connected to the lower bow carriage through flexible cables *d*, and a double-pole swiveling contact-maker *l*, while the other end *n* is connected to the car through one conductor of the double cable *p* and a cord to take the stress. The other conductor of the car cable runs continuous through the tubes, around the joint and swivel and up to the trolley carriage. The hinged tubes are normally closed together under the action of the spring *q*, but when the car starts, turns, etc., the arms open more or less, and prevent shocks being

*P. O. Box 151, Brussels, Belgium.

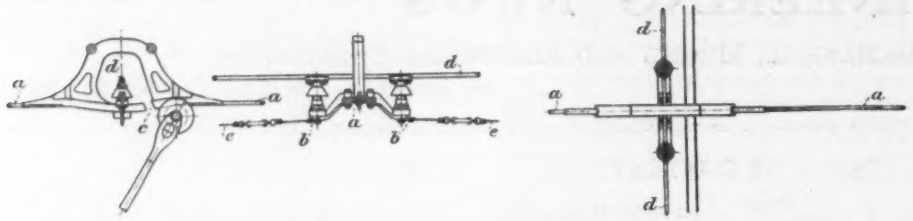


FIG. 2. CROSSING OF DOUBLE AND SINGLE OVERHEAD TROLLEY LINES.

transmitted to the collector itself. The collecting cables pass down an upright arm on the top of the car to a spring-controlled cable drum, which keeps the cable taut, and from which the current is conveyed to the motor through rubbing contacts. The whole arrangement has been found "quite satisfactory in practice."

As shown by Fig. 1, a double-track tramway line crosses the route of one of these 'bus lines. Special overhead construction was needed at this point, as shown in Fig. 2. Both lines were made dead for four meters from the crossing point by the insertion of ordinary section insulators in the case of the tramway lines, and by the interruption and insulation of the ends of the positive wire at *c* in the case of the rail-less line. The ends of the wire *e* are attached through strain insulators at *b* to the support of the tram wire *a*. A small gap, 1¼ ins. wide, is left in the cross-piece at *c*, through which the arm of the omnibus collector can pass.

The four-meter-radius dead interval at the crossing-place has normally to be got over without current; but if, by accident, a 'bus should stop on the dead section, it is only necessary for the driver to draw the collector by hand either forward or backward on to the live portion of the line in order to obtain a supply again.

Graphical Design of Shoes for Bands of Wood-Stave Pipe.

By E. A. MORITZ.*

Probably few engineers other than those connected with companies making wood-stave pipe are ever confronted with the problem of designing or analyzing the stresses in a shoe or clamp for the bands of such pipe. Occasionally, however, the problem is encountered; on these occasions the following graphical method will be found useful. The method is explained by selecting a concrete example and working out the problem in detail.

The shoes are made of cast-iron, malleable iron, or steel. The present analysis is applicable to all of these materials as long as the same general form is used, the only change necessary being in the unit-stresses. Malleable iron seems to be the most popular and best adapted for this purpose, and this material is used in the following analysis.

REQUIREMENTS.—The general requirements are:

1. The maximum bearing pressure of the shoe on the wood shall not exceed the maximum strength of the wood in crushing across grain.

2. The shoe shall be capable of developing the full strength of the band.

GOVERNING CONDITIONS.—The maximum stresses in the band and the maximum pressures on the wood occur during the process of cinching or drawing up the band, when the stress in the band may actually approach the ultimate. At such times the stresses in the two ends of the band are unbalanced, the difference being taken up by friction of the shoe on the wood. But it is possible for a band to be stressed excessively under service conditions, so that the stresses in the shoe should be determined also for the case when both ends of the band are stressed to ultimate strength. The pressures on the wood need not be analyzed for this case, as the base of the shoe has a much greater area than an equal length of band and excessive indentation need not be feared. The only danger involved in excessive pressures on the wood is that the pressure at the heel may become so great as to dig into the wood, thus injuring the stave and interfering with a proper adjustment of the shoe on the pipe.

*Sunnyside, Wash.

ASSUMPTIONS. — It is assumed: 1, That the point of application of the pull in the band is at the center of the head or nut, and that the direction of the pull is in the direction of the center line of the band; 2, That the stresses lie in the same vertical plane; and 3, That the angle of friction between iron and wood is 45°.

DATA.—The problem assumed for illustration is the design of a shoe for a ½-in. round band to be used on a 31-in. (inside diameter) pipe. The thickness of the staves is taken as 2 ins., which makes the outside diameter 35 ins. and the radius of arc of the bottom of the shoe 17½ ins. The ultimate strengths are assumed to be:

	Lbs. per sq. in.
Steel	60,000
Malleable iron, tension	48,000
compression	100,000
Douglas fir staves, compression across grain	1,200

The cinching end of the band is upset to 9/16-in. diameter and has cold-rolled threads. The type of shoe used may be seen from Fig. 1, which shows the final result of the design, or from the view Fig. 2. The dimensions given in Fig. 1 are the quantities to be determined.

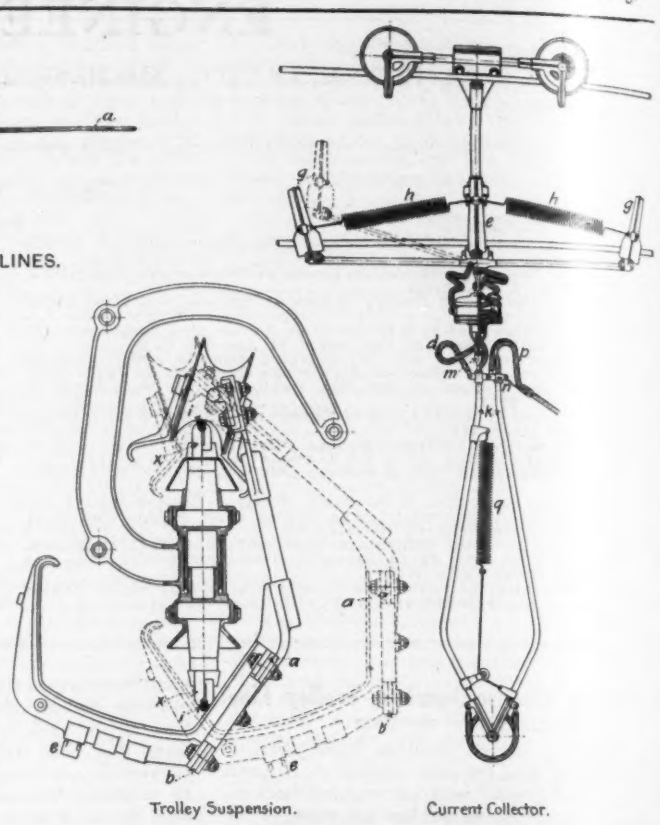
PROCEDURE.—Lay off an arc *f e g*, Fig. 3, with a radius of 17½ ins., and draw the two ends of the band in position, allowing about 1/16-in. clearance between the button head and the wood and 1/16-in. between the button head and the threaded end of band. The bearing face for the nut, *B V*, is made long enough to afford a proper bearing for the nut and washer, and the top thickness *Z V* should be not less than about ⅛-in.

Draw the center lines of the two ends of the bands and from their point of intersection at *a* lay off to scale *ac* = 11,800 lbs., the ultimate strength of the band. Draw *cb* parallel to *ad* and draw *ab* at an angle of 45° with the radius of the pipe through *a*. The resultant pressure of the shoe on the pipe when the shoe is on the point of slipping is represented by *ab*, which scales 7,000 lbs.

Next draw a trial base. The band should clear the base of the shoe at the heel *f*, Fig. 3. For convenience, the face *Bg* is made parallel to the radius of the pipe through *a*. The width of the toe is determined by the necessary clearance for the button head and the base width of the side webs of the shoe. The sum of these is assumed as 1⅞ ins., and the base made of uniform overall width equal to this width at toe. At the heel the base is solid, while in the center portion it consists only of a narrow strip at each side; the solid part of the heel is made 1½ ins. long.

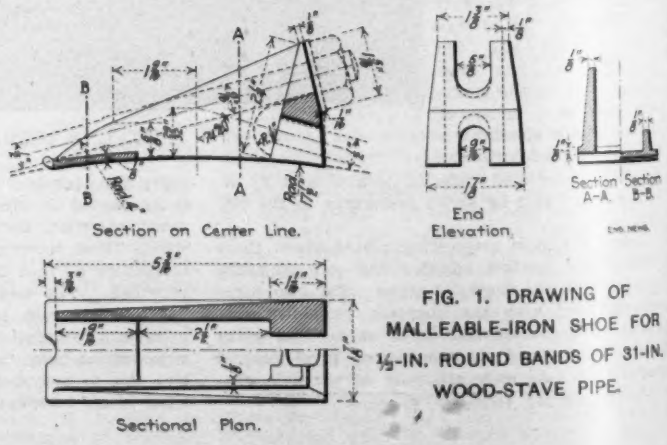
The area and location of the gravity axis of the base are readily determined analytically. The moment of inertia can also be computed, but is found with greater facility by graphical method (see Johnson, Bryan and Turneaure's "Theory and Practice of Modern Framed Structures," seventh edition, page 128). In the diagram of the base, in Fig. 3, the hatched portion represents the supplemental area called for by this method; to avoid a complication of lines construction lines are not shown in the drawing. The area of the base is found to be 6.06 sq. ins., and the moment of inertia 15.70 ins.

The resultant band-pressure of 7,000 lbs. strikes the base at a perpendicular distance of 0.36 in. from the gravity axis. The moment due to this eccentricity is $7{,}000 \times 0.36 = 2{,}500$ in.-lbs. From the flexure formula $S = Mc/I$ the increase in pressure at the heel due to this moment is $2{,}500 \times 2.14 \div 15.70 = 340$ lbs. per sq. in. The uniform pressure on the base is equal to *al*, the normal component of *ab*, divided by the area, or $5{,}000 \div 6.06 = 825$ lbs. per sq. in. The total pressure at *f* then is $825 + 340 = 1{,}165$ lbs. per sq. in. As this is slightly less than the allowable ultimate stress



Trolley Suspension. Current Collector.

FIGS. 3 AND 4. DETAILS OF TROLLEY SUSPENSION AND CURRENT COLLECTOR, BREMEN, GERMANY.



Section on Center Line. End Elevation. Section A-A. Section B-B. Sectional Plan.

FIG. 1. DRAWING OF MALLEABLE-IRON SHOE FOR ½-IN. ROUND BANDS OF 31-IN. WOOD-STAVE PIPE.

the base as designed is considered satisfactory. The stress calculation is not rigidly exact, as the wood is stressed almost to its ultimate, but the error is small and is on the side of safety.

Construct a moment diagram as in Fig. 4, in which the vertical distance from any point on xx to the moment curve represents the sum of the moments of all external forces to the left of this point. These forces are the base pressures, and are readily calculated with the aid of the bottom diagram in Fig. 3; for this purpose a diagram of stress intensities is convenient, but is not shown here. Two moment curves should be drawn, one for the stress conditions shown in Fig. 3 and one for the condition of ultimate stress in both ends of bands. The web sections are then to be designed for the condition giving the greater moments.

Assume several cross-sections of web, of different heights, one being shown in Fig. 4. Determine the gravity axis, moment of inertia, and resisting moment for each. These are found in the manner previously mentioned. The scale used may conveniently be several times the actual size. The resisting moment is now found from the formula $M = SI/c$, where S is the ultimate strength of malleable iron in tension (48,000 lbs. per sq. in.), and c is the distance from gravity axis to the extreme fibre on the tension side, this being the weaker side. This calculation again is not strictly accurate, because the formula does not apply beyond the elastic limit, but the method produces the proper balance between band strength and shoe strength for working stresses, which is the ultimate aim.

As an example of the procedure take the section shown in Fig. 4. The resisting moment of one web is here found to be 6,760 in.-lbs.; for two webs 13,500 in.-lbs. Enter the moment diagram with $M = 13{,}500$ as argument, and draw a horizontal line to intersect the moment curve at h. From h draw the vertical line hm. Draw mn perpendicular to the base, and of length 0.73-in., the distance from the gravity axis to the extreme tension fiber of the section. With n as a center and with radius 1.02 ins., the distance from the gravity axis to the extreme compression fiber, describe an arc. Proceed similarly with the other sections and obtain a series of such arcs. It is evident that the depth of web must be such as to include all these arcs. The broken line represents the top of the required web, but for practical reasons the solid line is adopted.

In the above method moments of external forces are taken about the base of the section, whereas to be strictly correct they should be taken about the neutral axis. The error from this source is slight and if it is desired to test a section exactly it may be done as in the following example:

Pass any section rs through the critical part of the web and draw it out in a similar manner to the other sections. Locate the gravity axis and determine the moment of inertia. Plot the position of the gravity axis f and drop a perpendicular to xx to intersect the moment curve at p. Then pq is the moment of external forces to the left of the section about the neutral axis. With the bending moment and the properties of the section known the stresses are readily calculated. Other sections may be treated in a similar manner. The region of minimum strength in the shoe is known by the proximity of the arcs to the top of the web, and in any shoe only the sections in the neighborhood of rs need be investigated by the exact method.

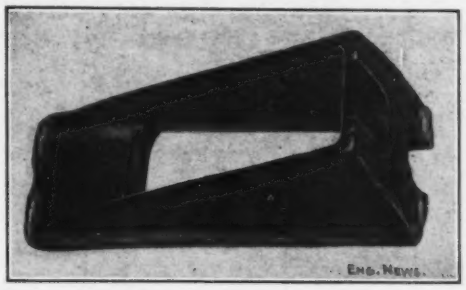


Fig. 2. View of a Shoe.

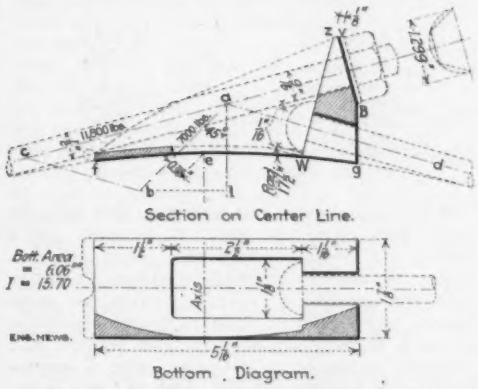


Fig. 3. Layout of Shoe, and Base Diagram.

The sections as determined above are sufficiently strong, but this does not necessarily mean that a section of less weight would not be just as strong. Just as in any other structural shape the width of the section might be diminished and the depth increased and the same strength maintained. Two or more analyses as above should therefore be made in order to obtain the most economical design.

PRACTICAL REQUIREMENTS.—The thickness of the base at the heel f, Fig. 3, is usually made about ⅛-in. The only stress that acts on it is the pressure from the wood, which causes a bending stress. But ⅛-in. or even less thickness is probably ample for this in any case; the stress can readily be calculated if desired. The shape and dimensions of the head g B V Z W, Fig. 3, are fixed by the necessary clearance and bearing surface required for the bands, and the width of base is also primarily determined by this requirement. The section at B is often subjected to great stress during construction on account of a tight fit of the band in the slots and it should therefore be made comparatively heavy, although theoretically it takes no stress.

It is evident that the cinching end of the band should not be in contact with the base at f. The face BV should be drawn in at B about 1/16-in., more or less, depending on the size of the shoe, in order to keep the band from springing out of the slot during cinching. A minimum of ⅛-in. is generally used for the thickness of the top of the web and the bottom is made sufficient to provide the necessary strength.

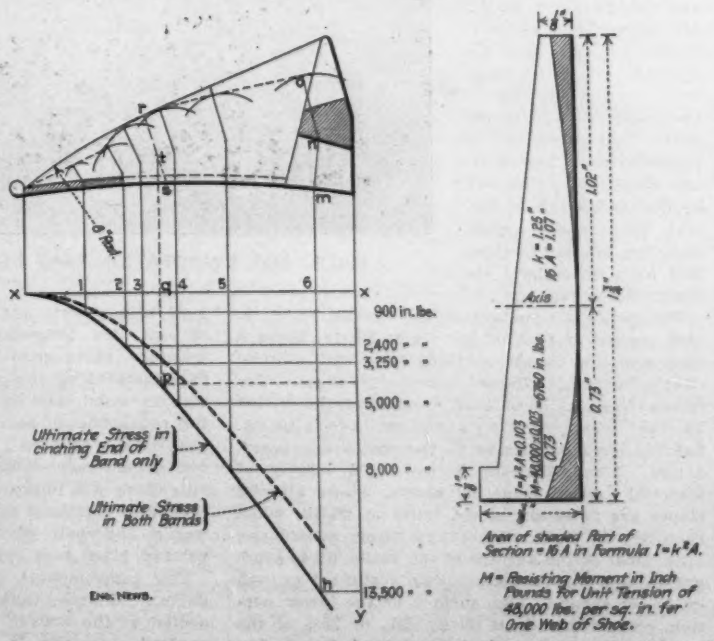

900 in. lbs.
2,400 " "
3,250 " "
5,000 " "
8,000 " "
13,500 " "
Ultimate Stress in cinching End of Band only
Ultimate Stress in Both Bands
ENG. NEWS.
Area of shaded Part of Section = 16 A in Formula I = k²A.
M = Resisting Moment in Inch Pounds for Unit Tension of 48,000 lbs. per sq. in. for One Web of Shoe.

FIG. 4. MOMENT DIAGRAM OF BASE PRESSURES, AND DETERMINATION OF WEB HEIGHT FROM ASSUMED SECTIONS.

Results of the Use of Energy Meters on Tramcars in Cape Town, South Africa.

In a paper before the British Institution of Civil Engineers (printed as No. 3912 in the Proceedings of the Session 1910-11, Part II.), Mr A. S. Giles gives the results of using wattmeters for measuring the actual energy consumed on the tramcars of Cape Town, South Africa.

The particular type of wattmeter used was specially designed to withstand the vibration of a car and seems to have been quite satisfactory. The lower pivot, instead of being solid with the armature spindle, is made of highly tempered steel and carries the weight of the armature through a spring. The jewel of this pivot is of itself spring-supported so that under vibration the jewel and pivot move up and down together. Vibration is absorbed in the two springs, and hammering of the pivot on the jewel does not take place. It is interesting to note that in this case the use of energy meters has been preferred to the various other recorders, notably the time-of-coasting clock in use in New York and in some European cities. (Eng. News, July 14 and Oct. 27, 1910.)

It was ascertained that in Cape Town the same car, driven under similar conditions and over the same route, showed a difference of 40% in the energy used by various motormen. Tests with specially equipped cars were made to find the causes for waste of energy. These showed that the trouble was largely faulty stopping and starting. For instance, some 14% of the energy required for starting was wasted by faulty acceleration, and energy was also unnecessarily wasted when approaching a stopping place by unskillful coasting or none at all.

In order to encourage more economical running, a bonus system for motormen was instituted. For each section of the system a reasonable energy figure was established, and all men averaging this figure during the week received a bonus of 62 cts. A careful log of meter readings and mileage is kept for each motorman driving the car. The results for each man are posted each week. The attachment of meters to all cars and the bonus system have led to a marked decrease in the power used and in the maintenance of equipment cost. A few items are shown in the accompanying table. For instance, there was a saving of 41% on maintenance of brakes and 14.8% in the average power consumption.

IMPROVEMENT IN OPERATION OF CAPE TOWN CARS AFTER INSTALLATION OF WATTMETERS.

	Before adoption, miles.	After installation, miles.
Average life of armature-bearings	23,450	33,766
Average life of motor-pinions	27,893	31,916
Average life of axle-bearings	58,750	92,333
Average life of car-wheels	45,833	55,833
Expenditure on brake-shoes	$1,595	$941
Average power used in 12 months KW-hrs. per car mile	1.814	1.546

Coasting Vessel with Crude-Oil Engines.—The Ardrossan Dry Dock & Shipbuilding Co., Ltd., Ardrossan, are building, for a Glasgow firm, a coasting vessel of 142 ft. × 25 ft. × 10 ft. 6 ins. draft, and the engine contract has been secured by Douglas, Primrose & Co., Engineers, Glasgow, for a four-cylinder "Bolinders" direct reversible crude-oil engine, of approximately 500 I. HP.—that is, of sufficient power to give the vessel a sea speed of 8½ knots. The vessel, if fitted with steam machinery, would carry 420 tons, but the saving in weight and space occupied by the oil engines increases this to approximately 480 tons. Steam steering gear, steam capstans and steam winches are being fitted, and these will get their power from a donkey boiler, fed with the same oil fuel as used in the main engine.—"Engineering."

The Measurement of Soil Evaporation Under Arid Conditions.

By CHARLES H. LEE, Assoc. M. Am. Soc. C. E.*

A subject of vital importance to water-supply engineers throughout the West, and in fact to any engineer engaged in the study of ground-water supplies, is that of soil evaporation. Ground-water which annually escapes into the atmosphere by this process from damp lands situated in the arid portion of the United States, if made available for human use, would irrigate much desert land which now lies idle, as well as furnish many small cities and towns with water more reliable in quantity and quality than that now derived from surface supplies.

The city of Los Angeles, in connection with the development of a water-supply for the aqueduct, has been carrying on experiments in Owens Valley, Cal., to determine the annual depth of evaporation from damp bottom lands for varying depths to the surface of saturation. The results of one year's observations are now available and have led to some interesting conclusions. A description of the method of measurement and discussion of the data obtained are presented in this article.

The rate of evaporation from soil depends upon: (1) the temperature of the air and soil, (2) the quantity of moisture already in the immediately surrounding atmosphere, (3) the amount of moisture in the surface layers of the soil, (4) the character of the vegetation and other soil covering. Temperature has the same effect upon evaporation from damp soil as from a free water surface and is the most important variable factor to be considered. The annual periodicity in evaporation rate results from the similar characteristic of temperature variation, and the rate during each 24-hour day also shows the influence of temperature. The amount of wind movement and the humidity of the atmosphere in immediate contact with damp soil surface are often of primary importance for short periods of time, but they occupy a secondary place when periods of more than a few days are considered.

The most important factor influencing soil evaporation is the amount of moisture in the top layer of soil. Experiments by the U. S. Department of Agriculture have fully established the fact that the loss of moisture from soil occurs from the soil grains at or near the surface which are in direct contact with the atmosphere. Hence the total amount of precipitation and the frequency with which it occurs, the depth to permanent ground-water surface, and the capillary characteristics of the soil are subjects intimately connected with soil evaporation. In a region of frequent precipitation the surface layer of soil is moistened at short intervals from the atmosphere, while in an arid region moisture in the soil is derived from water flowing upon the surface or from rising ground-waters. The capillary qualities of the soil determine the amount of precipitation or surface water which the soil will absorb, its rate of progress downward, and the amount which will be drawn back to the surface. It also determines the rate at which water will be drawn upward from a permanent ground-water surface, and the maximum depth at which capillary connection with the top layer of soil can be maintained. The depth to permanent ground-water surface determines the extent to which subterranean waters will be drawn upon by the process of soil evaporation.

Vegetation introduces a fourth factor into the problem of soil evaporation. Its influence is exercised in three ways; first, in the process of transpiration by which water is absorbed by plant roots and carried upward to the foliage where it escapes from the breathing pores; second, by protecting the soil surface from the direct rays of the sun and from wind movement; third, by the accumulation of dead root fiber in the soil which makes the soil texture more open and provides channels for the movement of capillary water. Transpiration is the most important of these effects, and is the means by which a large volume of water escapes into the atmosphere from the soil. It is most active during the growing period of a plant, but continues as long as the foliage is green. It differs with the species of plant, and with the same species when existing under different conditions of light, atmospheric pressure, soil texture, and available moisture in the soil. For a species growing in a given locality, light and soil moisture available to the root system are the controlling factors. The depth to which certain plant roots will penetrate in search of water is an important element in connection with the latter factor. The effect of shade is to reduce evaporation from the protected soil surface. Dead root fiber in the soil tends to increase the power of the soil to raise ground-water to the surface.

*Asst. Engineer, Bureau of Water Works and Supply, City of Los Angeles, Cal., P. O. address Independence, Cal.

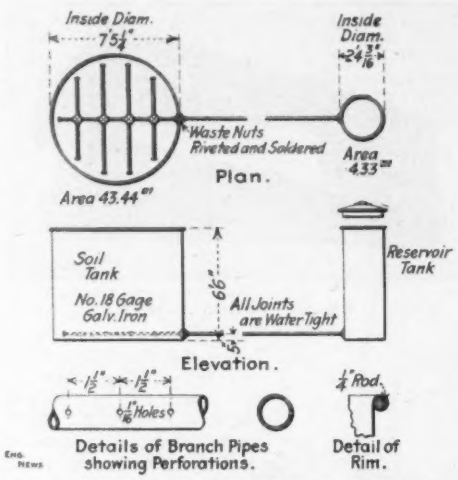


Fig. 1. Standards of Soil and Reservoir Tanks Used In Soil Evaporation Experiments.

The conditions under which experiments were carried on in the Owens Valley are distinctly arid. The number of storms each year which yield precipitation over the floor of the valley averages five; and the amount of moisture falling at any one time seldom exceeds 1 in. The mean annual precipitation at Independence is 5.26 ins. Humidity is low, especially during the summer, and dry winds are of almost daily occurrence during the spring and early summer. The average temperature at Independence is 58° F., with observed extremes of 105° and 3° F. Average monthly temperature and precipitation at Independence are given in Table I., and also the depth of evaporation from a pan floating on the surface of Owens River, four miles east of Independence. The average elevation of the valley floor is 3,800 ft. In general, the climatic conditions are similar to those met with throughout the Great Basin region.

The geologic structure of the Owens Valley is also typical of that of the Great Basin, being a deep synclinal trough partially filled with alluvial debris from the adjacent mountain ranges. The Sierra Nevada Mountains, bordering the valley on the west receive abundant precipitation, but the Inyo Mountains to the east are a desert range. The valley-fill is composed largely of material carried from the Sierra, whose alluvial slopes are from six to ten miles in width, while those at the base of the Inyo rarely exceed one mile. Most of the surface of the valley fill is sand, gravel and boulders supporting a stunted growth of desert shrubs. The surface of the lower portion, comprising about 65 sq. mi., or 25% of the whole, is covered with from 2 to 4 ft. of clay soil underlaid by strata of clay and sand. Most of this area is meadow land, which during the spring and summer months is in striking contrast to the surrounding desert. Salt grass is the predominating type of vegetation, although several varieties of fresh water grass are found near springs. Surface deposits of alkali are almost universal throughout the meadow land, and within limited areas is so concentrated that even salt grass does not grow. Permanent ground-water lies at depths varying from 3 to 8 ft., and in many places the soil is moist to within a few inches of the ground surface.

The source of this ground-water is percolation from precipitation upon the higher portions of the valley-fill, from mountain streams which flow across it, and from irrigation along the upper edge of the meadow land. Soil evaporation and transpiration are very active throughout the meadow land, and it is estimated from a series of comprehensive field measurements extending over a period of several years, that 80% of the water entering the valley-fill by percolation escapes in this manner.

The conditions under which soil evaporation was studied were, therefore, arid climate, a permanent ground-water surface lying from 3 to 8 ft. below the ground surface, and a predominently clay soil supporting a vigorous growth of native salt and fresh water grasses. The great difficulty in carrying on soil evaporation experiments is to reproduce natural conditions as regard atmospheric exposure of the isolated body of soil, its temperature, means of acquiring moisture, plant growth and capillary state. The experimental equipment was designed with this idea in mind, and it is believed that it fulfills the requirements as completely as is possible at a reasonable expense. Two conditions which were not satisfactory during the first season's work, but which will improve with time, are a fully established capillary connection between ground-water and soil surfaces and completely developed plant root systems.

The experimental equipment consists of two galvanized iron tanks, 6½ ft. in depth, connected at the bottom by an 18-ft. length of galvanized pipe (Fig. 1). The smaller tank is 2 ft. 4 3-16 ins. in diameter and is furnished with a

TABLE I.—TEMPERATURE, PRECIPITATION AND EVAPORATION AT INDEPENDENCE, CAL.

Month.	Average monthly temperature, Deg. F.†	Average monthly precipitation, ins.†	Depth of evaporation from water surface in ins.‡
Jan.	40.4	1.12	1.68
Feb.	44.6	0.77	2.45
March	49.4	0.61	4.92
April	56.8	0.17	7.18
May	62.8	0.17	8.94
June	72.6	0.06	10.00
July	78.6	0.12	9.45
August	76.2	0.15	8.10
Sept.	68.9	0.12	6.45
Oct.	58.7	0.29	4.05
Nov.	48.6	0.25	2.48
Dec.	40.2	1.43	1.54
Year	58.1	5.26	67.24

†Observations by U. S. Weather Bureau.
‡Observations by Los Angeles Aqueduct.

FIG. 2. SOIL EVAPORATION TANK NO. 3 IN OPERATION.

tight fitting cover. The larger tank is 7 ft. 5¼ ins. in diameter and has a system of branching perforated pipes at the bottom connected with the pipe from the smaller tank. The two tanks and all connections are water tight, and water poured into the smaller, or reservoir tank, passes through into the larger, or soil tank, and escapes through the perforations.

These two tanks were placed in excavations of a proper size to receive them, the soil tank filled with the excavated soil, and the reservoir tank filled with water. A 6-in. layer of screened gravel, too coarse to enter the 1/16-in. perforations, was laid in the bottom of the soil tank to insure an uninterrupted and well distributed feeding of water from the reservoir tank into the superimposed soil. As soon as the material became saturated and capillary action established to the surface, the water level in the soil was brought to the desired depth and kept there by supplying water to the reservoir tank in measured quantities. Volumeteric measurements of water poured into or withdrawn from the reservoir tank were made with an ordinary gallon measure. Accumulation or depletion of the supply in the reservoir tank was determined volumetrically by measuring the depth of water with a steel tape. The volume passing out of the reservoir tank during a given period represents the total evaporation from the soil tank during that period.

The position of ground-water surface in the soil tank was determined by measuring its depth below the ground surface in 2-in. diameter auger holes, bored in the soil to a proper depth. Measurements were made from a fixed point with a steel tape weighted at the end and chalked before each observation. Three holes were placed in each tank half-way between the center and rim on radii 120° apart. For reasons noted below some of the tanks were provided with six holes placed on radii 60° apart. The holes were not bored deep enough to reach the bottom layer of coarse gravel, and water level in them represented ground-water surface in the surrounding soil. An average of the observations made at a given time was assumed to represent the general depth to ground-water for the tank at that time. The tendency for the sides of the holes to cave-in, and the bottom to fill with sand was controlled by casing them with 2-in. galvanized sheet iron pipe, generously perforated with 1/16-in. holes. These were driven so that the top was flush with ground surface, and were closed with wooden plugs. In some of the tanks it was found impossible to bring the ground-water surface to the desired level with the available hydrostatic pressure from the reservoir tanks, and 2-in. holes were bored between the observation holes to the saturated gravel layer. Water usually rose in them to the same height as in the reservoir tank, and by seeping laterally into the soil, built up the ground-water surface. It was found difficult to keep these holes open down to the gravel, however, and water level in most of them eventually represented the ground-water surface.

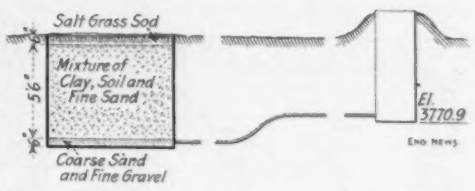


Fig. 3. Arrangement of Soil and Reservoir Tanks, No. 6.

Three tank sets were installed in the open valley floor east of Independence in February, 1909. The surface of Soil Tank No. 1 was bare sand, while Nos. 2 and 3 (Fig. 2) were laid with salt grass sod, which in the latter grew with vigor. The initial plan for Tank Sets Nos. 1 and 3 was to hold the ground-water level at various depths below the ground surface for periods of a few weeks during the summer months while climatic conditions were constant, and so obtain, in a short time and with few tanks, results of a general nature. The movement of the water surface from one level to another consumed so much time, however, that winter approached before the lower levels were reached, and furthermore, there was no accurate method of determining the volume of evaporated water represented by the differences in depth.

The experience of the first year's work with these tanks showed the necessity of a fixed ground-water level during a complete cycle of climatic changes. In Soil Tank No. 2 it was at first proposed to hold the ground-water level at or near ground surface, but so great was the rate of summer evaporation that this was found to be impossible with the equipment. To remedy the defect, the hydrostatic pressure from the reservoir tank was increased by soldering on an extension of 3 ft.; but this was not effective until late in the season. This experience suggested the desirability of placing the reservoir tanks above the soil tanks, and increasing the size of the feed pipe.

With these ideas in view, four additional tank sets were installed in January, 1910. The reservoir tank outlets were placed about 1.7 ft. above the soil tank inlets, and 1-in. pipe was used throughout (Fig. 3). The new soil tanks were laid with salt grass sod, which grew fairly well. In Tank Set No. 1 the depth of water in the reservoir tank was held at 6 ft. to maintain a uniform hydrostatic pressure in the soil tank, and thus reproduced natural conditions. No attempt was made in this set to control ground-water fluctuations artificially. In Tank Sets Nos. 2 and 7 water was supplied to the reservoir tanks in quantities such that the depths to ground-water were respectively 5, 4.5, 4, 3, 2 and 1 ft. Observations were carried on continuously in the seven tanks for a period of one year, in order to study the effect of the ordinary range of climatic conditions.

The detail of the soil evaporation observations made on Tank Set No. 6 is shown graphically in Fig. 4. The supply of water available to the soil from the reservoir tank is the element under complete control of the observer, and at the top of the diagram is a statement of the purpose governing additions to, or withdrawals from, this supply during various periods of time. Below this is plotted a broken line representing the fluctuation of water surface in the reservoir tank, the vertical portions indicating additions or withdrawals of the reservoir supply made by the observer, and the inclined portions the soil tank draft. There is also plotted a mass curve showing the aggregate volume of water supplied to the reservoir tank, which appears as a series of vertical and horizontal lines. Near the bottom of each diagram is plotted an undulating

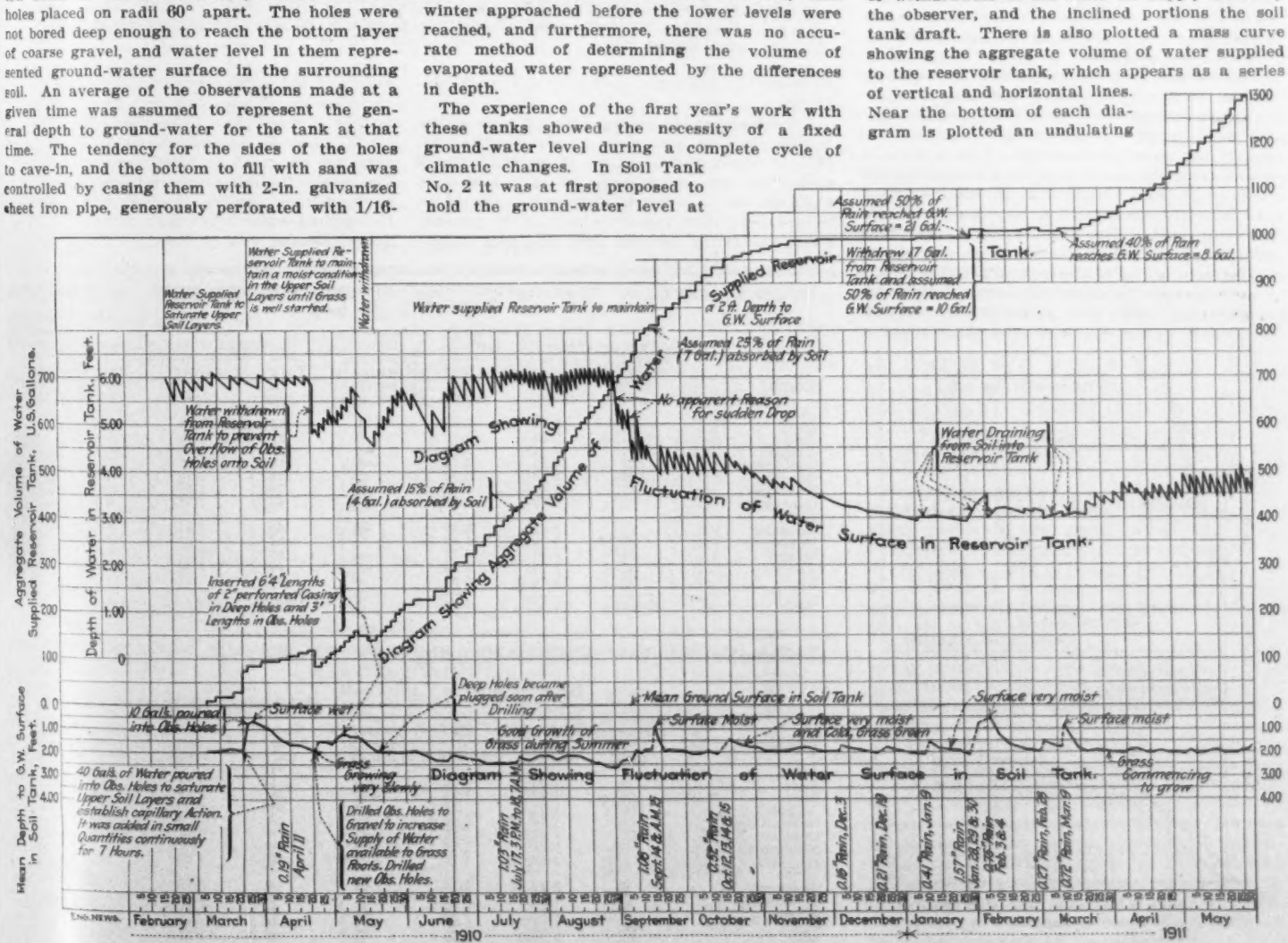


Diagram Showing Aggregate Volume of Water Supplied Reservoir Tank, U.S. Gallons.
Depth of Water in Reservoir Tank, Feet.
Diagram Showing Fluctuation of Water Surface in Reservoir Tank.
Water Supplied Reservoir Tank to Saturate Upper Soil Layers.
Water Supplied Reservoir Tank to maintain a moist condition in the Upper Soil Layers until Grass is well started.
Water withdrawn
Water supplied Reservoir Tank to maintain
Supplied Reservoir at 2 ft. Depth to G.W. Surface
Assumed 50% of Rain reached G.W. Surface = 21 Gal.
Withdrew 17 Gal. from Reservoir Tank and assumed 50% of Rain reached G.W. Surface = 10 Gal.
Tank.
Assumed 40% of Rain reaches G.W. Surface = 8 Gal.
Assumed 25% of Rain (7 Gal.) absorbed by Soil
No apparent Reason for sudden Drop
Water withdrawn from Reservoir Tank to prevent Overflow of Obs. Holes onto Soil
Water Draining from Soil into Reservoir Tank
Assumed 15% of Rain (4 Gal.) absorbed by Soil
Inserted 6'4" Lengths of 2" perforated Casing in Deep Holes and 3' Lengths in Obs. Holes
Diagram Showing Fluctuation of Water Surface in Soil Tank.
Mean Depth to G.W. Surface in Soil Tank, Feet.
10 Gals. poured into Obs. Holes
Surface wet
Deep Holes became plugged soon after Drilling
Mean Ground Surface in Soil Tank
Surface very moist
Surface Moist
Surface very moist and Cold, Grass Green
Surface moist
Good Growth of Grass during Summer
Grass Growing very Slowly
Grass Commencing to grow
40 Gals. of Water poured into Obs. Holes to saturate Upper Soil Layers and establish capillary Action. It was added in small Quantities continuously for 7 Hours.
Drilled Obs. Holes to Gravel to increase Supply of Water available to Grass Roots. Drilled new Obs. Holes.
0.19" Rain April 11
1.03" Rain July 17, 3 P.M. to 8 A.M.
1.08" Rain Sept. 14 & 15 A.M.
0.35" Rain Oct. 12, 13, 14 & 15
0.16" Rain, Dec. 3
0.27" Rain, Dec. 19
0.41" Rain, Jan. 9
1.57" Rain Jan. 28, 29 & 30
0.35" Rain Feb. 3 & 4
0.27" Rain, Feb. 28
0.72" Rain, Mar. 9
ENG. NEWS.
February March April May June July August September October November December January February March April May
1910
1911

FIG. 4. RECORD OF OBSERVATIONS ON SOIL TANK NO. 6.

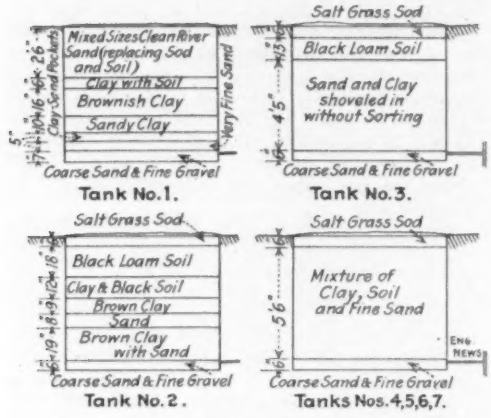


Fig. 5. Soil Conditions in Various Tanks.

line representing the fluctuation of ground-water surface in the soil tank, each depth being obtained by averaging the depths recorded in the observation holes.

The small part that precipitation plays in ground-water fluctuations in Owens Valley is well shown by this diagram. The average annual precipitation at the experiment station is about 4.38 ins., the season 1909-10 being normal and 1910-11 well above normal. At the bottom of the diagram is noted the dates and amount of precipitation for each storm. The observations showed that percolation water does not penetrate to depths exceeding 2.5 ft., unless more than 1 in. falls continuously on moist soil. Even then it does not appear to reach depths of over 4 ft. The problem of percolation from rainfall is, therefore, practically eliminated from the experiments. When rising ground-water was noted in a soil tank following precipitation, the volume of percolating water was estimated from the observed rise and included in the mass curve, as noted on the diagrams.

The amount of water evaporated from the soil surface of any tank during a given period can be computed accurately from the diagrams when the depth to ground-water at the beginning and end of the period is the same. This is done by noting from the mass curve the amount of water supplied to the reservoir tank during the period, and also the accumulation or depletion in the reservoir tank. The sum of these quantities, with their proper algebraic sign, gives the evaporation loss. For the case of differing depths to ground-water, however, the computations are approximate, since the proportion of absolute void space in the soil layer and the amount of

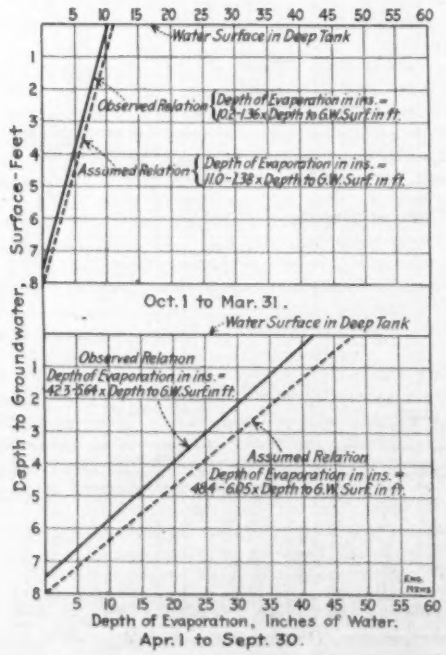

Water Surface in Deep Tank
Observed Relation
Depth of Evaporation in ins. = 1.02-1.36 x Depth to G.W. Surf. in ft.
Assumed Relation
Depth of Evaporation in ins. = 1.10-1.38 x Depth to G.W. Surf. in ft.
Oct. 1 to Mar. 31.
Water Surface in Deep Tank
Observed Relation
Depth of Evaporation in ins. = 4.23-5.64 x Depth to G.W. Surf. in ft.
Assumed Relation
Depth of Evaporation in ins. = 4.84-6.05 x Depth to G.W. Surf. in ft.
Depth to Groundwater, Surface-Feet
Depth of Evaporation, Inches of Water.
Apr. 1 to Sept. 30.

Fig. 6. Diagrams of the Relation of Evaporation from Soil and the Depth to Ground Water Surface.

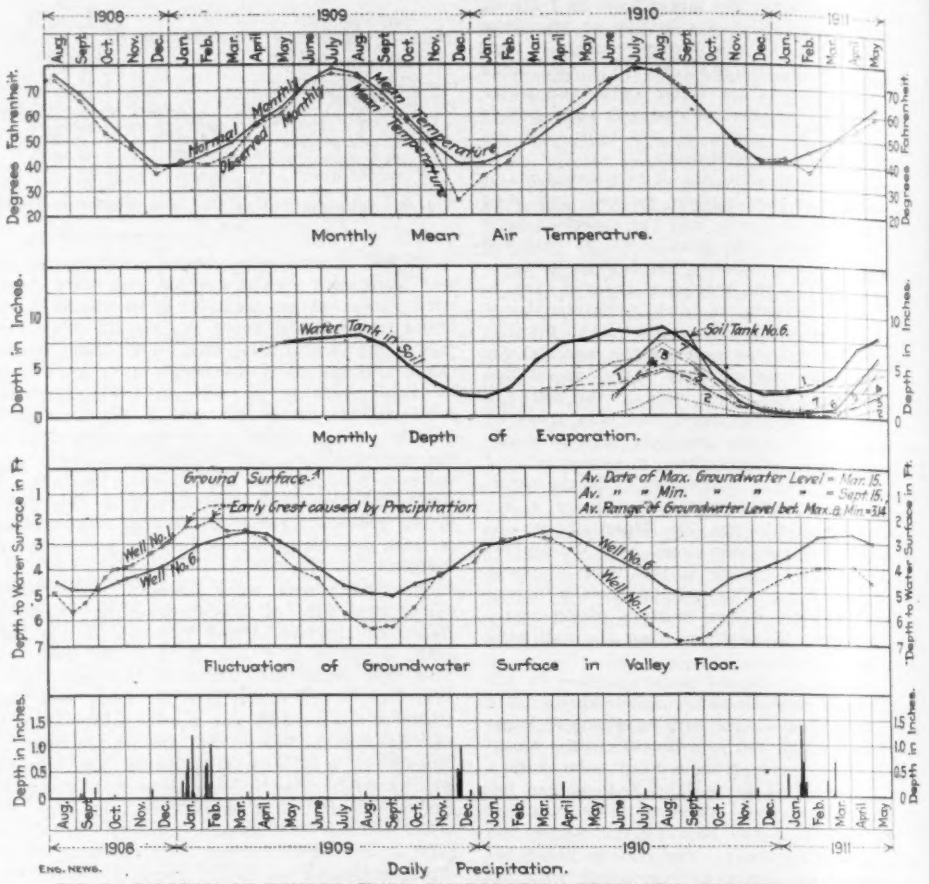

1908
1909
1910
1911
Degrees Fahrenheit.
Normal Monthly Mean Temperature
Observed Monthly Mean Temperature
Monthly Mean Air Temperature.
Depth in Inches.
Water Tank in Soil
Soil Tank No. 6.
Monthly Depth of Evaporation.
Depth to Water Surface in Ft.
Ground Surface.
Early Great caused by Precipitation
Well No. 1.
Well No. 6.
Av. Date of Max. Groundwater Level = Mar. 15.
Av. " " Min. " " = Sept. 15.
Av. Range of Groundwater Level bet. Max. & Min. = 3.4
Fluctuation of Groundwater Surface in Valley Floor.
Depth in Inches.
Daily Precipitation.
Eng. News.

FIG. 7. DIAGRAM OF TEMPERATURE, EVAPORATION FROM SOIL, PRECIPITATION AND FLUCTUATION OF GROUND-WATER SURFACE IN VALLEY FLOOR NEAR INDEPENDENCE, CAL.

moisture it contained initially are both unknown.

A summary of the results for each tank set by months, for the year June 1, 1910, to May 31, 1911, is represented in Tables II. to VIII. Fig. 5 shows the soil arrangement of each tank. In Tank Set No. 1 it will be seen that the draft on the reservoir tank varied as well as the ground-water surface in the soil tank, and that fluctuations of the latter only partially represent the variation in evaporation rate. The average difference of water level in the two tanks was only 1.2 ft., however, so that the pressure was probably not as great as under natural conditions. The results for this tank are thus not instructive in the manner desired. In Tank Sets Nos. 2 to 6 the ground-water level was maintained at the desired depths, but in Tank Set No. 7 the pres-

TABLE II.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 1.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	85	5.82	5.80	—1	86	3.18	.102	1.55
July	98	5.80	5.80	0	98	3.62	.117	1.47
August	121	5.80	5.91	+4	117	4.33	.140	1.45
September	113	5.91	5.73	—6	119	4.40	.147	1.23
October	103	5.73	5.82	+3	100	3.70	.119	1.26
November	67	5.82	5.72	—3	70	2.59	.086	1.04
December	68	5.72	5.83	+4	64	2.38	.077	0.92
1911								
January	70	5.83	5.89	+2	68	2.52	.081	1.06
February	87	5.89	5.89	0	87	3.22	.115	1.07
March	79	5.89	5.77	—4	83	3.07	.099	1.16
April	91	5.77	5.80	+1	90	3.33	.111	1.57
May	98	5.80	5.81	0	98	3.61	.116	1.59
Year	1,080	5.82	5.81	0	1,080	39.95	.109	1.28

TABLE III.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 2.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	0	1.49	1.33	—5	5	0.18	.006	4.70
July	22	1.33	1.23	—3	25	0.93	.030	5.01
August	60	1.23	1.36	+4	56	2.07	.067	4.99
September	44	1.36	1.42	+2	42	1.55	.056	4.91
October	17	1.42	1.21	—7	24	0.89	.029	4.92
November	7	1.21	1.13	—3	10	0.37	.012	4.98
December	5	1.13	1.10	—1	6	0.22	.007	4.97
1911								
January	6	1.10	1.15	+2	4	0.15	.005	4.98
February	0	1.15	1.11	—1	1	0.04	.001	4.95
March	3	1.11	1.14	+1	2	0.07	.002	4.94
April	10	1.14	1.18	+1	9	0.33	.011	4.94
May	30	1.18	1.19	0	30	1.11	.036	4.98
Year	204	1.49	1.15	—10	214	7.91	.022	4.94

TABLE IV.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 3.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	24	1.19	0.32	—28	52	1.92	.064	4.50
July	103	0.32	0.38	+2	101	3.74	.121	4.51
August	145	0.38	1.01	+20	125	4.63	.149	4.52
September	89	1.01	0.53	—15	104	3.85	.128	4.48
October	57	0.53	0.42	—4	61	2.26	.073	4.44
November	16	0.42	0.18	—8	24	0.89	.030	4.43
December	14	0.18	0.14	—1	15	0.56	.018	4.49
1911								
January	9	0.14	0.10	—1	10	0.37	.012	4.53
February	18	0.10	0.23	+4	14	0.52	.019	4.59
March	12	0.23	0.20	—1	13	0.48	.015	4.48
April	40	0.20	0.54	+11	29	1.07	.036	4.50
May	62	0.54	0.60	+2	60	2.22	.072	4.49
Year	589	1.19	0.60	—19	608	22.51	.062	4.49

TABLE V.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 4.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	54	2.16	2.29	+ 4	50	1.85	.062	4.07
July	128	2.29	2.84	+18	110	4.07	.131	4.11
August	146	2.84	3.03	+ 6	140	5.18	.167	4.08
September	81	3.03	2.62	—13	94	3.48	.116	3.96
October	65	2.62	2.71	+ 3	62	2.29	.074	3.99
November	16	2.71	2.22	—16	32	1.18	.038	3.84
December	—6	2.22	1.53	—22	16	0.59	.019	3.84
1911								
January	7	1.53	1.49	— 1	8	0.30	.010	3.97
February	—8	1.49	1.18	—10	2	0.07	.002	3.36
March	3	1.18	1.19	0	3	0.11	.004	3.74
April	62	1.19	2.15	+31	31	1.15	.038	4.00
May	96	2.15	2.57	+14	82	3.04	.098	4.06
Year	644	2.16	2.57	+13	630	23.31	.064	3.92

TABLE VI.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 5.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	69	3.04	3.88	+27	42	1.56	.052	3.11
July	151	3.88	5.09	+39	112	4.15	.134	3.00
August	169	5.09	4.73	—12	181	6.70	.216	2.97
September	117	4.73	3.90	—27	144	5.33	.177	2.92
October	83	3.90	3.56	—11	94	3.48	.112	2.94
November	17	3.56	2.95	—20	37	1.37	.046	2.89
December	4	2.95	2.55	—13	17	0.63	.020	2.96
1911								
January	8	2.55	2.43	— 4	12	0.44	.014	3.01
February	6	2.43	2.42	0	6	0.22	.008	2.47
March	3	2.42	2.36	— 2	5	0.18	.006	2.73
April	88	2.36	3.65	+42	46	1.70	.057	2.99
May	141	3.65	4.09	+14	127	4.70	.151	3.01
Year	856	3.04	4.09	+34	823	30.46	.084	2.92

TABLE VII.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 6.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft Beginning of month.	Depth of water in reservoir, tank-ft End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	119	5.50	5.65	+ 5	114	4.22	.141	2.15
July	156	5.65	5.76	+ 4	152	5.62	.181	2.31
August	209	5.76	5.50	— 8	217	8.04	.259	2.36
September	180	5.50	4.07	—46	226	8.36	.278	1.93
October	99	4.07	3.86	— 7	106	3.92	.126	1.85
November	25	3.86	3.38	—16	41	1.52	.051	1.89
December	0	3.38	3.03	—11	11	0.41	.013	1.85
1911								
January	12	3.03	3.19	+ 5	7	0.26	.008	1.92
February	9	3.19	3.17	— 1	10	0.37	.013	1.31
March	24	3.17	3.22	+ 5	19	0.70	.023	1.70
April	94	3.22	3.53	+ 7	87	3.22	.107	2.00
May	163	3.53	3.54	0	163	6.03	.195	1.99
Year	1,090	5.50	3.54	—63	1,153	42.67	.117	1.94

TABLE VIII.—DEPTH OF EVAPORATION FROM GROUND SURFACE NEAR INDEPENDENCE, TANK SET NO. 7.

Month.	Volume of water supplied reservoir tank, gals.	Depth of water in reservoir, tank-ft. Beginning of month.	Depth of water in reservoir, tank-ft. End of month.	Accumulation or depletion of water in reservoir, tank, gals.	Volume of water evaporated. Total in gals.	Volume of water evaporated. Depth in ins.	Volume of water evaporated. Rate in ins. per 24 hrs.	Average depth to ground water surface in soil tank, ft.
1910								
June	139	5.62	5.50	— 4	143	5.30	.177	1.47
July	166	5.50	5.91	+13	153	5.67	.183	1.57
August	198	5.91	5.98	+ 2	196	7.26	.234	2.03
September	152	5.98	5.91	— 2	154	5.70	.190	1.82
October	111	5.91	6.01	+ 3	108	4.00	.129	1.70
November	50	6.01	5.79	— 7	57	2.11	.070	1.18
December	3	5.79	5.07	—23	26	0.96	.031	0.63
1911								
January	3	5.07	4.70	—12	15	0.56	.018	0.73
February	31	4.70	5.08	+12	19	0.70	.025	0.81
March	67	5.08	5.90	+26	41	1.52	.049	0.98
April	102	5.90	5.96	+ 2	100	3.70	.123	1.46
May	151	5.96	5.92	— 1	152	5.62	.181	1.64
Year	1,173	5.62	5.92	+10	1,164	43.10	.118	1.34

sure from the reservoir was not sufficient during the months of April to September to hold the water level at the 1-ft. depth. The average head of water in the reservoir tanks during the six months April to September, inclusive, for Sets 2 to 7 was 0.22, 0.59, 1.68, 2.02, 2.20 and 2.61 ft., respectively, indicating that a progressively greater pressure is required to maintain the ground-water level at the shallower depths. As the average summer depth to ground-water in Soil Tank No. 7 was 1.67 ft., it would require a maximum head of possibly 3.5 ft. to supply water in sufficient quantities to meet the evaporation demand from ground-water at the 1-ft. depth.

The annual depth of evaporation from the various soil tanks exhibits a consistent decrease with increase of depth to ground-water, and varies from 43.1 ins. for No. 7, to 7.9 ins. for No. 2. The depth of summer evaporation varies from 77% to 83% of the annual in the several tanks, and averages 79%. The month of maximum evaporation is August, while minimum values occur most often in February. The exact times of maximum and minimum evaporation rates occur early in September and late in March, respectively. The approximate dates of maximum and minimum air temperatures at Independence are July 10 and Jan. 10, respectively, but no measurements were made to determine the lag of corresponding soil temperatures at various depths. The extremes of evaporation from water surface agree in time of occurrence with maximum and minimum air temperatures, however, and the observed lag in soil evaporation is, in general, consistent with observed lag in soil temperatures in other localities. Hence it is reasonable to conclude that extremes in soil evaporation rate and soil temperature are concurrent at a given depth.

A graphical study of the data in Tables II. to VIII. for the periods April 1 to Sept. 30, and Oct. 1 to March 31, which are periods of increasing and decreasing evaporation rate respectively, is presented in Fig. 6. There appears to be a straight line relation during each period between total evaporation and depth to ground-water. The limiting depth is apparently 7.5 ft., and the total evaporation when water and ground surface coincide is 42.3 ins. and 10.2 ins. respectively. Representing the total depth of evaporation in inches by E, and the depth to ground-water in feet by D, the equations expressing variation in evaporation with depth to ground-water are: $E = 42.3 - 5.64\ D$, and $E = 10.2 - 1.36\ D$. Capillary conditions and plant root systems have not reached their natural state in most of the tanks, although each year of maintenance brings the equipment nearer perfection, as can be seen by noting that total May evaporation in 1911 exceeds that of June, 1910, even though temperatures during early 1910 were above normal, and during early 1911 below normal. Tank No. 6 probably represents conditions most nearly normal since capillary action is strong at that depth and plant roots have not far to go to reach water. Observations of depth to water in transition zones between meadow and desert land at many points in the valley indicate that soil evaporation ceases at a depth of 8 ft. instead of 7.5 ft. From these considerations lines are assumed which it is thought more nearly represent natural conditions, their equations being $E = 48.4 - 6.05\ D$, and $E = 11.0 - 1.38\ D$.

In connection with the soil evaporation experiments observations were made of evaporation from the surface of water in a circular tank 3½ ft. in diameter and 4 ft. deep, set in the soil with the upper rim flush with the surface. Water was not allowed to fall more than 4 ins. below the rim in this tank. Observations were made with a hook gage set in a stilling-well. The temperature of the water was considerably modified by the surrounding soil. Evaporation from this tank during the summer months represented approximately the theoretical evaporation from soil with zero depth to ground-water, as can be seen by consulting Fig. 6. The depth of evaporation during the period Oct. 1 to March 31, however, is twice that indicated by the diagrams.

CONCLUSIONS.—An interesting confirmation

of the activity of soil evaporation from the meadow land is exhibited by ground-water fluctuations. Numerous well records kept within this area, and the adjacent desert land to the west, show that there is a distinct type of fluctuation which occurs throughout the meadow land and enclosed areas, but which does not appear elsewhere. This fluctuation is regular and periodic with comparatively narrow and fixed limits. When the observations are plotted on a basis of time, Fig. 7, they take the general form of the sine curve with an annual periodicity. The average time of occurrence of crest, as observed in 122 wells distributed generally over the meadow land, is March 15, the troughs occur Sept. 15, and the average amount of fluctuation between maximum and minimum levels is 3.14 ft. Furthermore, in areas outside the meadow land where the depth to ground-water exceeds 8 ft., there is no alkali crust on the surface of the ground, and no capillary connection between ground-water surface and the top layer of soil. Hence it is concluded that soil evaporation is confined to the meadow land, and is in some way connected with the type of ground-water fluctuation observed there.

The curve of monthly depth of soil evaporation as observed in the several tanks has a form very similar to that of ground-water fluctuation with the position of crests and troughs reversed. (See Fig. 7.) The dates of maxima for the one correspond with the dates of minima for the other in summer and the reverse is true in winter. Hence the relation between soil evaporation and the observed ground-water fluctuation is one of cause and effect. This periodicity of fluctuation in shallow wells has often been noted in humid regions, but under such conditions that it is impossible to ascertain the cause with as great certainty as in this case.

The general method by which the dissipation of ground-water into the atmosphere can be prevented is suggested by the observations, namely, by providing some means by which the surface of saturation can be kept at or below the limiting depth at which soil evaporation will occur. The loss will then cease, and the means by which it is accomplished, whether by pumped wells or deep drainage ditches, will deliver an equivalent volume of water that can be put to beneficial use. The concentration of alkali in the upper soil layers which usually accompanies rising ground-waters would also be under control, and the drained land fitted for agricultural purposes. There is yet much to be done in this direction before complete use can be made of the available water-supply of the Western States.

Service Equipment of the Pennsylvania Tunnels and Terminals, New York City.*

By GEORGE GIBBS,† M. Am. Soc. C. E.

(Concluded from p. 406.)

Tunnel Facilities.

SIZE OF TUNNELS.—The height was carefully considered by the Board of Engineers and the Committee of Operating Officers. A minimum was fixed for the depth of the ballasted form of track and a minimum of clearance over the top of the cars in which to provide for wrecking operations and for the possible use of an overhead electric conductor for traction, should developments require it. The adopted clearances are as follows:

Total length of single-track tunnels.	15.54 miles
Total length of river tubes.....	12.02 "
Inside diameter of tube tunnels.....	19.00 ft.
Distance from top of rail to crown of tube tunnel arch.....	16.00 "
Minimum top clearance over car roof to crown	1 ft. 9 ins.
Distance from tunnel invert to top of rail	2 ft.
Height of top of tunnel benches above rail	5 ft. 6 ins.
Width between benches	11 ft. 8 ins.
Width of bench (River sections)....	3 ft. 8 ins.

*Abstract of a paper to be presented before the American Society of Civil Engineers, Oct. 18, 1911, on "The New York Tunnel Extension of the Pennsylvania R. R.; Station Construction, Road, Track, Yard Equipment, Electric Traction and Locomotives," printed in the May Proceedings, p. 636.

†Chief Engineer of Electric Traction and Station Construction, Pennsylvania Tunnel & Terminal R R. Co., Pennsylvania Station, Seventh Ave. and 32d St., New York City.

The circular cross-section provided an excess of clearance horizontally, which President Cassatt suggested might be utilized for high side benches of concrete, which would form vertical walls for the protection of trains in case of derailment, for walkways for passengers, in case of accidents, and for employees. They also conveniently and safely house the electric cables. Fig. 6 shows a section of the interior of the tunnel with signal equipment and other facilities.

LIGHTING.—The tunnels are lighted continuously by circuits independent of the traction system, and each tunnel, moreover, has two circuits independent of each other and fed from separate transformers and switching panels. The primary source of the lighting current is located in the Long Island power house and in the station service plant. Tungsten lamps (25-watt, 20-cp., 33-volt) are used, connected eight in series on a 252-volt circuit. The lamps are 50 ft. apart on each side of the tunnel, and the circuits are staggered so as to give a lamp for each 25 ft. of tunnel length. Enameled steel reflectors throw the light in the direction of traffic. Control of lighting current is from switchboards in the auxiliary-power substations in the tunnel shafts.

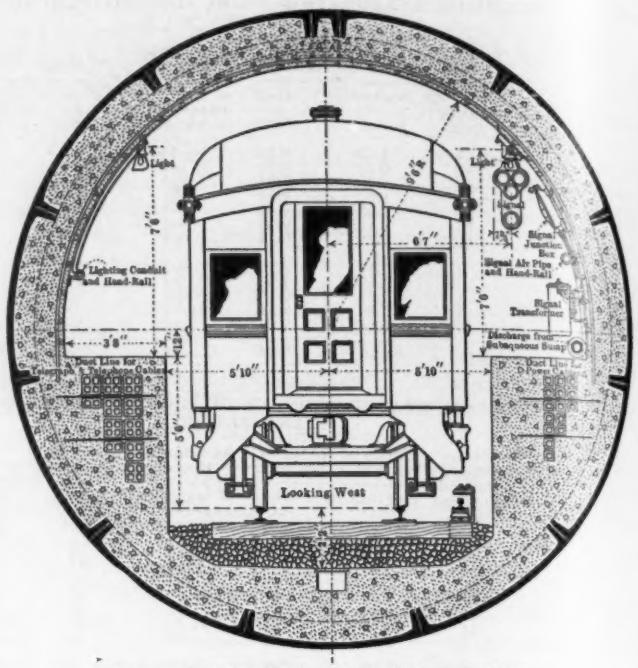


FIG. 9. CROSS SECTION OF RIVER TUNNELS.

VENTILATION.—Satisfactory tunnel ventilation was considered of great importance so that the tunnels should be safe under all emergency conditions and that there should be at no time noticeable discomfort to passengers. Two general conditions were provided for; (1) Purity of the air in normal operation, and (2) ventilation for an indefinite period, in case of stoppage of traffic. A special ventilating system was needed only to provide air to a stalled train in an emergency or to dissipate smoke and fumes from an electric arc, since the piston action of the trains would be an effective means of changing the air. The company engaged Mr. C. S. Churchill, M. Am. Soc. C. E., as expert consultant in these matters. To ensure not more than eight parts of CO_2 in 10,000, 50 cu. ft. per min. needs to be furnished per passenger to the tunnels. The total quantity of air required per section on this basis is about 60,000 cu. ft. per min., which will completely change the contents of the tubes three times per hour.

The system devised by Mr. Churchill for the Norfolk & Western Ry. was adopted. It is a forced-draft system, in which a constant and uniform current of air is induced in the tunnel by forcing in the direction of traffic the required volume of air into the portal. A divided nozzle in the form of a tapering flue is placed on each bench wall for this purpose. Two exhausting, instead of pressure, blowers are used to induce the return current of air at the west end of the cross-town tunnels, where they merge into the three-track tunnels approaching the station, the object being to prevent blowing air from the tunnels under and into the station building. The average velocity of the air in the East River tunnels, due to the action of the fans alone, is about eight miles per hour, and this is increased by the passage of trains to more than 30 miles. It is evident that in regular operation the fans need not be used, and they may be started and stopped from two central points: (1) the power house for the East River tunnels and (2) the service plant for the North River tunnels.

TUNNEL ALARM SYSTEM.—A special safety device has been installed, which has two functions; (1) to cut off current from a given section of the third rail, and (2) to send a fire-alarm call. The system comprises a series of alarm boxes about 800 ft. apart. Each box is numbered and contains two levers, colored blue and red, respectively. The blue lever is marked "power" and, when pulled, trips the circuit-breakers controlling the third-rail section adjacent to the box, cutting off the power. At the same time it sends a call of two rounds of the alarm-box number to the connected indicators. The red lever marked "fire" performs the same function, but sends two additional rounds of the box number. Indicators recording the character of the alarm and location of the box are in the offices of the train director, train dispatcher and power director, in the power substation controlling the traction current for the section in trouble, and in the interlocking switch cabin controlling train movements to that section.

In case of a partial short circuit, or in case it is desired to work around defective apparatus under a standing train, the power may be cut off from the third rail of this section by pulling the "power" lever. In case of a serious fire or other emergency, the "fire" lever may be pulled and the railroad fire department and emergency crews will respond. In either case, the person pulling the lever is instructed to communicate with the

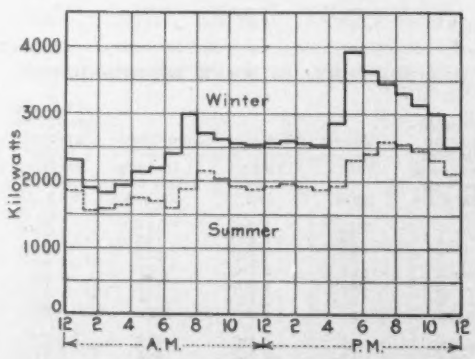


Fig. 7. Auxiliary Power; P. T. & T. R. R.

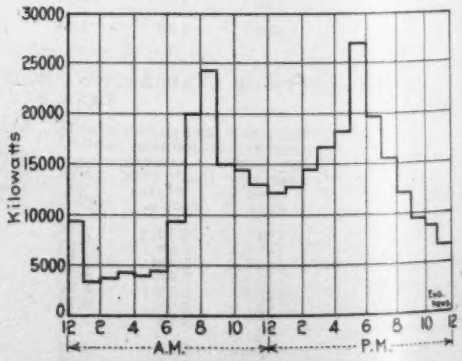


Fig. 8. Traction Power; P. T. & T. and L. I. R. R.'s

FIGS. 7 AND 8. ESTIMATED DAILY LOAD DIAGRAMS.

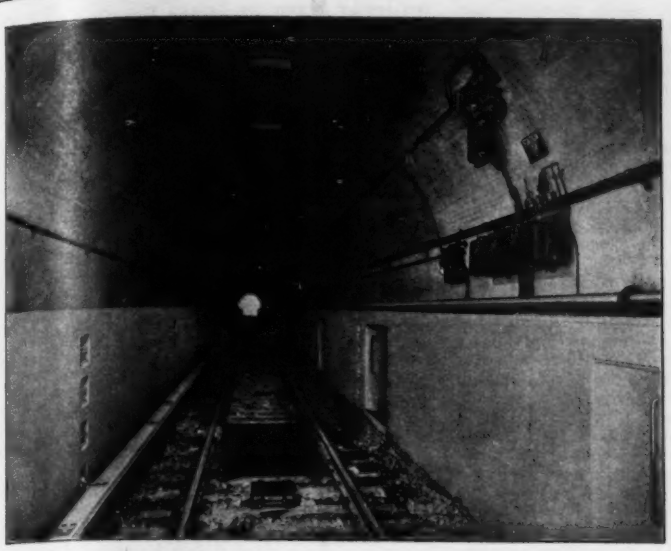


FIG. 10. INTERIOR OF RIVER TUNNELS, SHOWING SIGNAL EQUIPMENT.

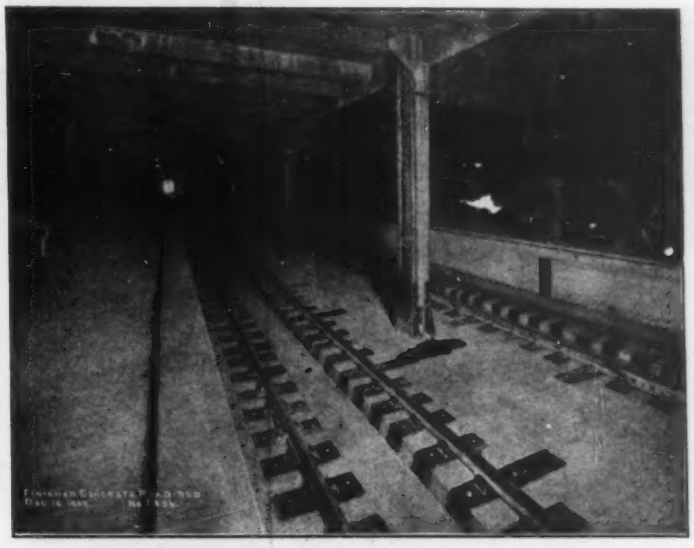


FIG. 11. CONCRETE TRACK CONSTRUCTION AT PLATFORMS.

train director by telephone from one of the nearby telephone boxes and to explain the trouble, so that an order governing subsequent procedure may be given.

TRACK.—The standards adopted are in general those of the Pennsylvania R. R., with certain modifications in detail to suit local conditions. For high-speed running with a minimum of vibration, to reduce noise and to permit of easier renewal, it was decided to adopt ballasted track rather than any special form built into the tunnel structure. The ties are of black gum and yellow-pine, creosoted, 18 ties to a rail length of 33 ft. All track is tie-plated, and under each plate is a pad of compressed hair felt, the tie being dapped out to receive the pad. The rail is secured to the tie through the plate by two 1-in. lag screws, each bearing on the rail flange and shoulder of the plate. The ballasted track was used through the switches and in the storage yard of the terminal, but a concrete base track was used adjacent to the platforms.

In the latter case it was desired to provide construction with a smooth surface which could readily be kept clean. To devise the proper form, a special committee was formed of operating officials of the Pennsylvania R. R. This committee recommended a special form of track laid on wooden blocks embedded in a concrete base. In general, the concrete surface was laid on the rock of the sub-grade, but in places it was necessary to use rod reinforcement or bridging in the concrete.

The track was first laid complete with its fastenings to the tie-box, and then raised and leveled with great care to the proper grade and alinement by hanging a structure from timber bridging carried on the station platforms. The concrete mixture was then poured, tamped and allowed to set before the bridging was removed. Fourteen thousand, six hundred feet of this type was laid adjacent to the platforms, the cost under the special conditions being $6.27 per lin. ft. for the base and $2.67 for the blocks and fastenings, giving a total of $8.94 per lin. ft. To test the application of this type of track to high-speed running, two short sections were laid in the East River tunnels.

YARD LIGHTING.—The open portion of the station yard is lighted by 18 3,000-cp., long-burning flaming-arc lamps 40 ft. above the tracks. In the Sunnyside yard the illumination is effected by 41 similar lamps, mounted on steel poles 200 to 350 ft. apart. The Manhattan Transfer Station yard is similarly lighted by 13 flaming arcs on concrete poles.

Electric Power System.

As the use of a tunnel entrance into New York City was predicated on electric traction, a statement of conditions met and investigations leading up to the determination of the system will be of interest. In 1902, when the terminal work was commenced, there were few practical examples of heavy electric traction, and none of the magnitude and complexity of the proposed terminal operation. Therefore, a complete program of experimental work was laid out for some years in advance of the time when the actual installation would be required.

About the same time, a portion of the Long Island R. R. was electrified, using the so-called third-rail or direct-current system, which might be more properly called "alternating-current direct-current." This system was practically the only one in a sufficiently advanced state of development to warrant its adoption. Later, the single-phase system was offered and was adopted on important work. In investigating the relative merits of the two systems, a special committee, composed of the heads of motive power departments of the Pennsylvania Lines East and West and of the Long Island R. R., was formed to cooperate with the writer in determining the proper system.

For investigating the practical behavior of the two systems, and in order to try out certain features of single-phase operation under tunnel conditions, an experimental line five miles long was constructed on a branch of the Long Island R. R. An equivalent of a tunnel section was installed and equipped with a high-tension overhead conductor. Various contact devices, designed for sparkless connection were tried. A multiple-unit equipment and a special alternating-current locomotive were used, both obtained from the Westinghouse company.

In the main these tests demonstrated the need of considerable further experimental work to adapt the alternating-current system to tunnel and yard conditions. The recommendations of the committee was for the adoption of the direct-current system because of (1) reliability from the start; (2) freedom from complication in exchange with the Long Island system and the Newark rapid-transit line through the Hudson and Manhattan tubes into New York, and (3) less expenditure at the present and for some time to come.

LOAD CONDITIONS.—The load conditions include both traction and auxiliary power and the requirements of the Long Island R. R. for traction. Considering all these, the load center was at a point adjoining the railway lines in Long Island City and not far from the water-front of the East River. Finally, it was decided to establish only one power house for present operation and to equip it for both traction and auxiliary power supply. Two power plants were not considered advisable, for reasons of economy, service, etc. An emergency supply of power for traction can be secured through connections at three different points with the stations of (1) Public Service Corporation of New Jersey, (2) the Hudson & Manhattan R. R. Co. in New York, and (3) New York & Queens County Ry. in Long Island City. As an emergency supply for the auxiliary power, the service plant at the station is equipped with apparatus capable of supplying the requirements of the entire system. The combined load conditions for all services are shown in Figs. 7 and 8.

The central power plant has been designed to care for these loads with sufficient reserve for ordinary emergencies and a limited amount of spare capacity in the building for growth. It has not been designed to take care of the general extension of the traction system through to other Pennsylvania lines. When these extensions are made, additions can be made to the present power-house building or a new power house can be erected on the New Jersey side.

CENTRAL POWER STATION.—The Long Island City power house is on the East River at a location nearly central to the present load conditions and close to the tunnel lines. The building of the plant was undertaken some years prior to the completion of the tunnel system in order to care for the electrified lines of the Long Island R. R. Power for this operation has been furnished since 1905.

The site was partly under water, with solid rock at a depth of 35 to 60 ft. below high water, the intermediate strata being of clay, sand and gravel. A pile foundation was driven and covered with a monolithic concrete cap 6 ft. 6 ins. thick.

The building is a steel-frame structure, with brick curtain walls. It is of fireproof construction throughout. The boiler-room is double decked, and the engine-room adjoins with switching galleries at the side. Coal is stored above the boiler-room in pockets having 5,200 tons capacity. A complete fire protection system has been provided, though chiefly because of the hazard from adjoining buildings. The machinery equipment of the power house, excluding the traction substation, may be concisely given as follows:

Coal pocket at top of building; capacity, 5,200 tons.
32 564-HP. water-tube boilers, 200 lbs. working pressure, 125° superheat. Space for 16 additional 564-HP. boilers.
Boilers equipped with 32 Type D, Roney stokers, 150 ins. wide, 12 grates deep.
Two 8,000-KW., 11,000-volt, three-phase, 25-cycle, turbo-generators, and space for one additional, for traction power.
Three 5,500-KW. 11,000-volt three-phase 25-cycle turbo-generators, for traction power.
Two 3,000-KW. 11,000-volt three-phase 60-cycle, turbo-generators, for auxiliary power.
One 200-KW. motor-driven exciter.
One 50-KW. motor-driven exciter.
Two 200-KW. turbine-driven exciters.
One 600-amp.-hr. storage battery of 110 cells.
One Tirrill regulator for 25-cycle generators.

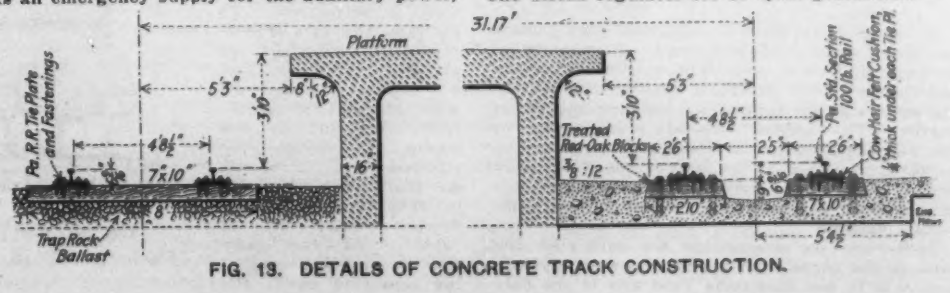


FIG. 13. DETAILS OF CONCRETE TRACK CONSTRUCTION.

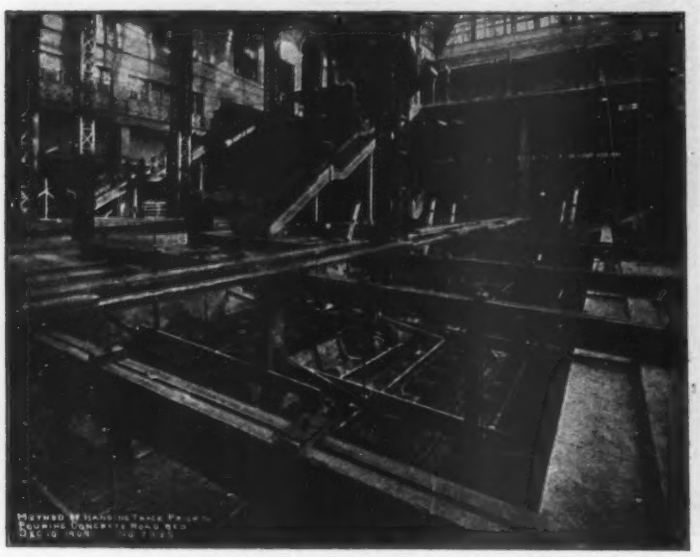


FIG. 12. SUPPORT OF TRACK STRUCTURE DURING CONCRETING.

One Tirrill regulator for 60-cycle generators.
Three 175-KW. oil-cooled transformers.
13 1,200-amp. 11,000-volt type C oil circuit-breakers.
39 600-amp. 11,000-volt type C oil circuit-breakers.

Switchboard:
One bench-board, eight panels for control of 25-cycle generators; and three panels for control of 60-cycle generators.
Six 25-cycle generator panels.
Two 60-cycle generator panels.
Two 25-cycle station panels.
One 60-cycle station panel.

TRANSMISSION LINES.—The transmission from the power house is entirely 11,000-volt, three-phase, the traction power being 25-cycle and the auxiliary power 60-cycle. The distribution is by three-conductor paper-insulated lead-covered cables communicating with the tunnels. This voltage is sufficiently high for economical transmission for the distance at which power is used at present. To provide for the contingency of an extension on the New Jersey side beyond Newark, space has been provided on the pole line across the meadows for 33,000-volt transmission. In the event of such requirement, step-up transformers would be provided at the Hackensack portal. As there are four tunnels under the East River, the various cables are subdivided into groups and distributed through the tunnels so that there is a duplication of routes. Each cable is provided at each end with a high-tension automatic oil circuit-breaker, disconnecting switches and section bus-bars so as to give complete control of the cables when in operation and permit the isolation of one or more for repair purposes without interfering with the operation of the remaining cables or sections. Where the cables are exposed, the lead sheathings are connected and grounded for protection against electrolysis.

TRACTION SUBSTATIONS.—Station No. 1 has been placed in the central power house and supplies the East River tunnels, the Sunnyside Yard and the Long Island tracks through the yard to a point where the load is taken by the first substation of the latter road. No. 2 is in the service plant adjoining the main terminal as already noted. No. 3 is at the Hackensack portals, because of the desirability of having the power supply near the tunnel grades, and to permit of changing from underground cables to overhead transmission at the first point where such changes are permissible. No. 4 is at the junction of the Terminal and New York Division, making it available for supplying power also to the rapid-transit line between Newark and Jersey City in connection with the Hudson & Manhattan Co.'s tunnels.

In each substation is installed high-tension switching apparatus, step-down air-blast transformers, and three 2,000-KW. rotary converters, together with the necessary low-tension switching apparatus for controlling the outgoing direct current. The normal direct-current voltage is 650, and the machines are designed to operate up to 200% overload on account of the fluctuating nature of the load. The third unit of each station is a reserve, and space is provided for an additional machine.

There are six substations for supplying the tunnels and yards with auxiliary power. Substation A is in the Sunnyside Yard and is the only one using 25-cycle current. Station B is in house over the shafts of Tunnels 3 and 4 at Long Island City. Stations C and D are over the First Ave. shaft of Tunnels 3 and 4 and 1 and 2, and Stations E and F are at the Eleventh Ave. and Weehawken shafts, respectively, of the North River tunnels.

SWITCHING STATIONS.—Intermediate between the traction substations are located switching stations in chambers built in the tunnel system and in small buildings adjacent to the line in the open. These stations are not manned with attendants, but contain switches for sectionalizing and cross-connecting the direct-current third-rail system. With two exceptions, these switching stations are equipped for remote control of switches and circuit-breakers and are operated from the nearest traction substation by special control circuits. The two which are equipped with hand-controlled apparatus are at or near signal cabins, where they can be operated by the signal men.

DISTRIBUTION.—The direct-current traction circuits in general consist only of the third rail and the track return with the short cable connections between the substations and the rails and tracks. The only exception is between Substations 3 and 4, where it is necessary to supplement the third rail and track return by a positive and a negative feeder.

It is necessary, in order to avoid undue loss and excessive first cost, to connect all substations in parallel through the third rail and to interconnect the third rails of the two tracks at intermediate points between substations. The grounding of the third rail under these conditions would ordinarily affect the entire section, and to permit of ready isolation of any section of track without interfering with operation on adjacent tracks a system of sectionalizing was installed. To do this, the switching stations referred to have been provided in addition to the normal switching apparatus in the substations. The circuit-breakers are automatic at both points so that an overload or short-circuit cuts out only the section between the substation and the nearest switching station and on one track only. In the yards, a complete system of sectioning is also provided, which is necessary because of the multiplicity of tracks and the necessity for isolating a limited section only. In the station yard the tracks are divided into 21 sections.

In addition to these provisions, the third rail in each tunnel is subdivided into sections, each about 1,500 ft. long, by quick-break knife switches. They are located approximately at each of the signals, and where the signals are far apart they are placed halfway between. They may be opened in emergencies so as to localize the trouble and will allow trains not immediately within this section to be operated out of the tunnel and to allow wrecking trains to operate close to the point of derailment.

Additional provisions have also been made to prevent a train from running onto a dead section of third rail. To do this, the rail is sectioned at certain of the automatic signals and a relay is provided with connections to the third rail and to the signal, to which the circuits are arranged, so that when the rail is dead the signal indicator will be at "stop." At the same time a gong will ring at the signal to notify the motorman when he brings his train to a stop that he is not to proceed.

THIRD RAIL.—The top-contact type in use on the Long Island R. R. has been found satisfactory. The cost of maintenance is low and it has the advantages of simplicity, flexibility, ease of maintenance and installation and of easy repair in case of derailment. A rail of large cross-section and special composition was used, requiring in most cases no supplementary feeder.

The rail used on the main line tracks is the heaviest yet adopted, being 150 lbs. per yd. Where the large conductivity has not been needed and maximum clearance is desired, the section used is a 25-lb. standard Bessemer T-rail mounted in an inverted position, the foot of the rail constituting the contact surface. The construction is shown in Figs 14 and 15. A simple and substantial insulating block has been used for supporting the third rail. These are of dry-process porcelain, which gives a tough and strong insulator. For open sections of the road a simple rectangular block with rounded corners is used. In the tunnels a petticoat type is used.

The heavy rail section is bounded with ribbon-type, compressed-terminal, foot bonds having a conductivity of 80% that of the rail. The third rails are protected throughout by a continuous plank carried on wrought-iron brackets. On the open line the plank is of yellow pine, but in the tunnel Jarrah wood is used.

CROSS-OVER CONTACTS.—To provide continuous power supply to locomotives passing through certain cross-overs and the ladder tracks of the station yard, it was found necessary to supplement the third rail by sections of overhead contact. This also permitted simplification of the third-rail system in the complicated special work of the tracks, and allows more space for the switch-operating apparatus. It has been assumed that for minor movements and for single or two-car multiple-unit operating, coasting over gaps in the third rail will be permissible.

The overhead contact consists of a 25-lb. standard section T-rail hung flange downward through insulators from longitudinal, latticed box girders. Under the buildings and viaducts these girders are supported by the floor structure. In the open yard they are carried by cross-girders from columns between tracks.

The locomotives* are equipped with air-operated overhead pantograph shoes, which may be raised by the motorman to make contact with the overhead rail. The contact surface of the latter is sheathed with heavy sheet-copper to reduce sparking. Multiple-unit motor cars have not been provided with these pantographs, and no overhead contact system has been found necessary in the Sunnyside or Manhattan transfer yards.

TELEGRAPH LINES.—Ultimately the telegraph and telephone service will require 60 open wires and two 40-pair cables. To make this line entirely secure against probable interruption by storms or grass fires, it was decided to substitute a line of concrete poles for the usual wooden ones. There were 202 such poles required, spaced from 70 to 135 ft. apart, varying from 25 to 50 ft. in height. The design was made by Mr. R. D. Coombs, M. Am. Soc. C. E. Because of the unusually heavy line and extra weight of the poles, foundation grillages were used, consisting of six

[* For a description of the Pennsylvania Electric locomotive see Eng. News, Nov. 11, 1909.—Ed.]

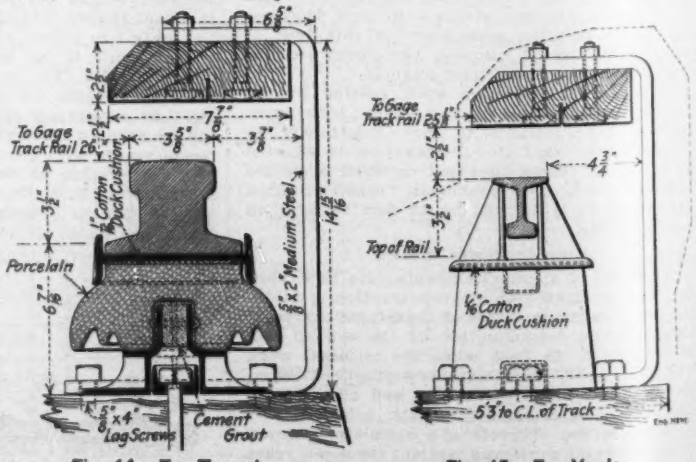
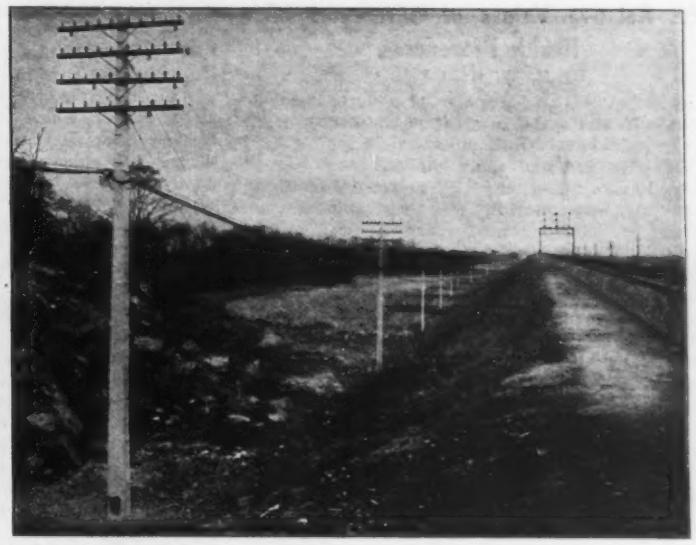


Fig. 14. For Tunnels. Fig. 15. For Yards.

FIGS. 14 AND 15. THIRD-RAIL CONSTRUCTION OF THE PENNSYLVANIA TERMINAL.



FIGS. 16 AND 17. STEEL AND REINFORCED-CONCRETE POLE LINES ACROSS HACKENSACK MEADOWS.

cross-ties bolted together and to the pole. The pole projected below the grillage and was pointed at the butt.

TRANSMISSION-LINE.—The wires for transmission of traction current from the tunnel portal to the Harrison substation, No. 4, were carried on a line of steel poles along the southern edge of the right of way. These poles are set 300 ft. apart, and are designed to carry seven three-wire transmission circuits additional. The poles are of latticed steel, square in cross-section, with a parabolic outline. In crossing the Hackensack River two towers 181 ft. 4 ins. above high water were used to secure the clearance specified by the War Department over navigable streams. The lowest wire of the crossing is 137 ft. 4 ins. above high water. The towers are of the same general outline as the poles, but of heavier section and larger dimensions. The pole foundations are of concrete on eight to ten piles, depending on the size of pole, the piles being driven from 30 to 80 ft., as required.

Telephone and Telegraph Service.

The telephone system for the terminal and tunnels comprises a complete installation for official and public uses and was planned jointly by the telegraph department of the railway company and the New York Telephone Co. The official equipment provides for service between the various departments of the terminal division and of the Long Island R. R. It consists of a main private-branch exchange having trunk lines to the telephone company's general exchange system, tie lines to other private exchanges in the various offices of the railway company, extension lines to the various offices in the station building and a special switchboard for the information bureau of the station.

The board is arranged for six operators with all connections in multiple. It connects with 25 monitor boards varying in capacity from 10 to 30 lines, and located in the power-house, substations, and signal cabins. The train dispatcher, having a selector bell-ringing circuit, may call up any one of the interlocking cabins without calling any of the others, or he may call them all in multiple and talk to all at the same time. A system of magneto telephones provides for direct calls through these switchboards from 140 outlying points.

Magneto sets have been placed conveniently on the tunnel walls above the side benches. A key with each set permits of connection to any one of four circuits extending through the tunnels; one to the main private-branch exchange board, a second to the power director's monitor board, a third to the interlocking cabin and a fourth is spare. There are 53 such sets at an average of about 1,500 ft. apart.

The telegraph system was planned by the telegraph department of the railroad. It connects with the general system of that road and with the Long Island R. R., and includes the Postal Cable Co.'s connections in the station.

It was first planned to conduct train movements by telephone, but after due consideration, on account of the new operation and a desire to use experienced "block" men who were telegraph operators, it was thought best to provide them with telegraph block wires by which the chief train director could hear all orders over the circuits. Allied to and supplementing the telegraph system are so-called "train dispatchers" used in the interlocking cabins between Newark, N. J., and Winfield, L. I. They constitute a mechanical telegraph system registering by disks on dials different train designations and routes.

For transmitting messages or orders in written form as a matter of record, or to supply advance information of train movement simultaneously to various offices and interlocking cabins, a Gray telautograph system has been installed.

Signaling.

As the rapid movement and safe control of trains are essential, the switch and signal system was made unusually complete. The physical conditions were exceptional in the following respects: (1) The yard is practically underground and the view is obscured by various structures; (2) clearances are limited; (3) character and extent of train movements required fullest utilization of all track facilities, necessitating the greatest freedom for simultaneous parallel movements; (4) complexity of track plans and presence of yard-service facilities demanded that the signal appliances should be mounted on special foundations and that control circuits should be in permanent and accessible shape.

The control of yard movements was divided between four different cabins; one near the west end of the yard for movements from the North River tunnel portals to Eighth Ave., one near and east of Eighth Ave. for the important tail switching of Long Island suburban trains, one at the Seventh Ave. portal of the 33d St. tunnels, where the yard tracks are gathered into groups leading into two of the East River tunnels and one similarly located under Seventh Ave. at the throat of the 32d St. tunnels. These cabins required a certain amount of interconnection to insure rapid and complete movements, a result accomplished partly by electric locking between cabins, partly by indicators on track models in the cabins (to show how the tracks between them are occupied and when trains are approaching) and partly by telephone communication with the train director.

As the tunnels require train movements over heavy grades at high speed and at the minimum safe interval, automatic block signals with overlaps of the same length as the block sections were adopted; in other words, a two-indication block, in which a "proceed" indication requires that two sections shall be unoccupied. The "caution" indication must show that at least as much track is unoccupied as in the foregoing. In each block in the tunnels, a track stop is installed to apply the brakes automatically should a danger signal be overrun.

Lock-and-block control has been provided between the station and Long Island approach of the East River tunnels, so that if necessary any one of the four tunnels can be operated in the reverse direction. The North River tunnels have the same provision with the addition of automatic signals for the following movements.

The Meadow Section has been equipped with automatic block signals without track stops. Complete reverse-movement signaling has been provided for at each block. At the Manhattan transfer yard two very complete electro-pneumatic interlocking plants are provided, controlling all main-line switches from the Passaic River to the separation of the New York and Terminal divisions at the east end. At the Sunnyside yard two interlockings were required, two for main line movements to and from the tunnels and for the Long Island R. R. movements through the yard and two for yard switching proper.

The signal (Rudd and Rhea) consists of a three-position arm to combine the functions of two signals having but two positions each with the movements of the arm from horizontal to vertical through the upper quadrant. The fact that the signal is automatic is conveyed by pointing the blade for day indication and by a fixed staggered light underneath at night. Interlocking signals are of multiple-arm with square end and vertical lights, the top arm for high speed, the second for limited speed and the lower one for low speed. In the station yard one speed-signaling only is used; that is, a high-speed arm permits movement at the highest permissible speed and a lower arm is provided for use only when a "proceed" indication cannot be given by the upper arm.

Because of the absence of daylight conditions in the tunnels, the use of signals having arms became of secondary importance and prompted the elimination of the arms from all block signals there, and from all but the ground or dwarf signals in the station area, indications being entirely by lights.

The control of all signals is secured automatically by track circuits. In the station yard these various functions were required of these circuits to permit of the most flexible movement under obscure physical conditions: (1) circuits as substitutes for detector bars; (2) for switch and signal control; (3) for route locking; and (4) for indication on the track models in the cabins.

As the traction current is direct, the signal current is alternating. Continuity of the rail circuits for the traction current is maintained past the signaling blocks by copper induction bonds, which allow the traction current to pass without material hindrance, but choke back the alternating current sufficiently to operate the signal relays. In the three yards, one rail only is used for the return traction current, the other being given up for the signal-control circuits. This is practical and economical here because of the high carrying capacity of the parallel tracks. Elsewhere all rails are used for propulsion return and for signal operations as well.

All interlocking machines are of the well-known electro-pneumatic type. Compressed air is used for the mechanical operations in the interlocking plants, for the track stops in the tunnels and for the signals on the Meadows section. Electric power operates the control circuits for interlockings, track stop control, block signals in the tunnels and yard and signal lights on the Meadows.

Candles for Emergency Lighting are provided along the walls of the foot subway through which passengers walk from the Hudson tube station to the Erie R. R. terminal in Jersey City. The candles are enclosed in glass cases to be broken in case of failure of the electric lights.

The Relative Values of Different Public-Health Procedures.

By H. W. HILL,* M.D.

To what extent are the procedures usually "lumped" under the head of public-health work really public-health measures?

While in a broad sense almost every act of every human being may be correlated directly or indirectly with "health," yet by a general consensus of opinion almost every civilized nation has limited public-health work to those measures which are believed to control the spread of disease and chiefly certain of the communicable diseases.

But the funds available to health departments are usually allotted to them by inexpert bodies. They are rarely divided on a logical and business-like basis, or distributed where they will accomplish most in the restriction of disease. They are devoted usually to the maintenance of more or less valuable traditional mechanisms supposed to relate to the control of disease, but enquiry is seldom, if ever, made as to the relative values of the different mechanisms in reducing disease, or even whether or not any such value really inheres in them.

Let us consider specific instances. In certain communities in Minnesota over a quarter of a million dollars is spent under the caption of public-health and sanitation. At least seven-eighths of this sum in each instance is devoted to street cleaning, garbage collection and the care of sewers. Which of the diseases properly public-health concerns are affected by any one of these three measures?

STREET CLEANING.—No one dreams that measles, scarlet fever, rabies, diphtheria, typhoid fever, mumps, whooping cough, chickenpox, leprosy, etc., are increased or diminished by the condition of the streets. We know that these diseases are spread almost solely by direct or nearly direct contact with infected persons (or animals). The failure to find that tuberculosis is disseminated to any appreciable extent by street dust, and the negative results of investigations carried on in England regarding the possible dissemination of smallpox by the wind, eliminate those two diseases from serious consideration here.

The popular belief that at least sore throats, pink eye and colds may be derived by infection carried in dust has never been conclusively proved, although the belief that some relation exists may have a basis in fact; while the writer's own suggestion, based on the views of previous investigators, that poliomyelitis may be so derived is as yet merely an incomplete hypothesis. Street cleaning, *as it is usually done*, cannot be trusted to eliminate this alleged source of disease, because such cleaning *to the point of getting rid of infection* is rarely if ever accomplished by present methods, since it would require thorough cleaning, day after day, in every thoroughfare, all over the city.

Let us suppose an impossibility: That as much as 10% of the cases of tuberculosis receive infection from "dirty streets." Such infection is and must be deposited on the streets almost entirely by infected persons, about 130 to 150 of whom exist on any one day in every 100,000 of Minnesota's population. (Very occasionally, perhaps, the streets may be infected by the deposit of the manure of infective cows.) The infected sputum may be deposited anywhere in the city, chiefly, however, in the vicinity of the homes of the actively infective tuberculous. A city of 500,000 people has many miles of streets and twice the length of sidewalks. The, say, 750 persons *who alone can infect with tuberculosis* are likely to infect the sidewalks which are not officially cleaned, rather than the street proper, where the efforts and money of the municipality are spent; moreover, they do not infect the downtown streets only, i. e., those which are most often cleaned, but also, perhaps chiefly, the suburban streets.

If there were one iota of evidence that street dirt contributes a serious percentage of the total number of cases of tuberculosis, or one iota of reason in the belief that if the streets are infected, present street-cleaning measures would remove the infection, or if there were any single item of proof that the most ideal methods possible for the removal of infection applied to the street proper, where infection is little deposited, leaving most of it untouched on the sidewalks, where it is chiefly deposited, could seriously reduce the dissemination of the germs, still there would be no excuse for laboriously and at tremendous expense cleaning all the streets in a really painstaking and thorough manner *to reduce tuberculosis* when all that is truly necessary to avoid danger by this route is to prevent from spitting on the streets the 750 people *who alone can infect the streets.*

This means knowing who the 750 are, and so supervising them—placing them under such restraint, moral and legal—as would prevent their further use of the streets as spittoons.

Incidentally such knowledge of the infectious persons, such supervision and control of them, would provide, at half the cost of such street cleaning, against the spread of this disease in the *remaining 90% of other ways*, infinitely more important; would, in short, provide for the comprehensive effective handling of the whole tuberculosis problem, not merely the alleged partial solution of a suppositious 10% of it.

To prevent misunderstanding, let me say that I do not decry street cleaning, even of the kind usually done, as a public utility, essential to convenience and comfort, probably of advantage in preventing (in so far as it prevents dust) minor irritations of the mucous membranes. No one objects to dust and dirt more than I do, and I am wholly willing to pay my share to escape it. But to regard street cleaning, even if perfectly performed, as a serious factor in the reduction of the spread of cases, disabilities or deaths from communicable diseases is to hold an untenable position; nor can anyone seriously considering the subject find any evidence for such belief in the literature, or even evolve a reasonable hypothesis in his own mind to support it.

SEWAGE DISPOSAL. — *The proper disposal* of sewage is of the greatest public-health importance, so far as involves the getting rid of the human discharges it contains in such a way that they are not reincarnated raw—do not reach the consumer's mouth in a raw state in his drinking water or on his raw vegetables. But the maintenance and operation of sewage disposal systems are not public-health measures, since they do not affect disease, always provided the discharges in the sewage are properly disposed of.

Supervision of the installation and extension of sewerage systems and oversight, which should include analytical safeguards, by public-health departments, are essential, but the daily grind of administration is not health department work.

Sewerage systems are not essential to the proper disposal of human discharges, although extremely convenient and highly to be desired. A sewage-disposal system may at times be a distinct menace to its own community, as in Two Harbors, Minn., where a water-supply, receiving a part only of the miscellaneous surface drainage of its community in pre-sewerage days, was invaded, after the installation of sewers, by the concentrated human discharges of the whole newly sewered district.

There is no public-health advance in the simple installation or maintenance of a sewerage system in and for itself. The only point of public-health importance is the prevention of human discharges, whether in a sewerage system or out of it, from entering human mouths. Sometimes the sewerage system which is of benefit to one community carries disease and death to another below it. Certainly no sewerage system which facilitates the exchange of human discharges can for a moment be considered as conserving the public health.

GARBAGE COLLECTION AND DISPOSAL, which are essential to comfort and convenience, are not (in sewered cities) affairs which greatly, if at all, affect the incidence of disease. At most their relation to the spread of infection is indirect, and that they have any relation is chiefly due to the fly-breeding function of the garbage. Garbage collection, alone, especially as it is usually done in most municipalities, does not much affect the number of flies and the most perfect garbage collection will at most reduce, not abolish flies, especially if manure is allowed to accumulate in the neighborhood. Flies breed more readily in manure than garbage, and to remove garbage while leaving manure is simply "saving at the spile and wasting at the bung." Let me once more urge that garbage collection and disposal, as details of municipal housekeeping, are admirable and never-to-be-sufficiently advocated forms of activity. They should be conducted under public-health supervision, but (in sewered cities) they are only most remotely and indirectly public-health measures. The administrative details of garbage collection and disposal do not relate to public health at all.

In unsewered communities garbage collection and disposal are of considerable importance, if combined with strenuous cleanliness as regards stable manure, because, in unsewered communities, the flies have access to open toilets (as they do not in properly sewered communities) and hence carry typhoid fever, dysentery, etc., directly. The utmost care regarding garbage is practically useless even in unsewered communities, if manure accumulates freely in the neighborhood, because flies will breed therein regardless of the presence or absence of garbage.

These considerations lead to the inevitable conclusion that if health-department activities in the Minnesota communities mentioned prevent any disease, disability or death at all (and I believe they do), the number of such saved divided into the cost of saving them will give from $10 to $1,000 expended per case prevented—*every cent spent for this purpose coming out of about one-eighth of the total appropriation* to the health department. The whole remaining seven-eighths of the appropriation cannot be shown to save even one case of disease, disability or death. If, however, we allow the hypothesis that as much as three deaths a year in each community could be saved by all the street-cleaning, garbage-disposal and sewerage-system administration in that community, they would be saved at an expenditure of about $100,000 a year apiece; enough, if applied along true public-health lines, to prevent from 300 to 30,000 cases, with their corresponding disabilities and deaths.

The account stands thus:

For the prevention of 40-4,000 cases (with their disabilities and deaths) annually by real public-health measures, i. e., $10 to $1,000 per case (including deaths)	$43,000
For the alleged prevention of at most 3 hypothetical deaths annually by street cleaning, etc., i. e., $100,000 per death...	350,000
Total expenditures for "health and sanitation"	$393,000

To sum up, garbage collection and disposal, street cleaning, the maintenance of sewers, etc., have little if any effect in reducing disease, disability or death, essential as their proper conduct is to general comfort, convenience and decency. One should urge clean back yards, alleys and streets as one urges clean clothing and neatness in general—because they are pleasanter and better and more attractive—not because they prevent disease. People buy new clothes because they like to look nice, not to ward off smallpox or tuberculosis. So with municipal housekeeping. The funds spent for "looking nice" should not be confused with those spent to prevent disease, disability and death.

[This general subject is further discussed in a condensation of a public address by Prof. Edwin O. Jordon and in an editorial published elsewhere in this issue.—Ed.]

*Director, Epidemiological Division, Minnesota State Board of Health, Minneapolis, Minn.

Irrigation in Oregon has been reported on by the U. S. Bureau of the Census. The total irrigated area of the state in 1909 was 686,129 acres against 388,310 acres in 1899—an increase of 76.7%. The area irrigated with water raised by pumping was 5,711 acres in 1909. The total cost of the irrigation systems of Oregon was $12,689,044 in 1910 against $1,843,771 in 1899—an increase of 588%. The average cost of operation and maintenance per acre in 1909 was 75 cts against 22 cts. in 1899.

Profitable and Fruitless Lines of Endeavor in Public-Health Work.[1]

By EDWIN O. JORDAN.[2]

It is well recognized to-day by many experts that while some of the ordinary activities of municipal health departments are of unquestionable value in conserving the health of a community, others are relatively ineffective or possibly worthless. One well-known writer[3] has thus expressed himself on this point:

> I boldly assert that if every case of communicable disease were promptly reported to the proper local board of health and as promptly placed under effective sanitary control and so kept until danger of infection had passed, all the other present-day activities of boards of health, whether local, state or national, with the exception of those directed against certain causes of infant mortality, and the possible further exception of some food and drug inspection, might be dropped with no appreciable effect upon the general health or mortality of any of our states or most of our cities.

In all fairness it must be admitted that a part of the energy of almost every municipal health department in this country is devoted to combating imaginary dangers or applied to tasks that have only a remote bearing on the public health.

This condition, as a rule, is not due to ignorance on the part of health officials, but to the pressure of public opinion. Such pressure is often exerted directly through legal ordinances passed by uninformed legislative bodies, but sometimes also through agitation by mistaken enthusiasts or through other channels of public opinion. Back of the whole situation is the existence in the public mind of wrong or antiquated conceptions of disease and the causes of disease. It was unfortunate in many respects for the cause of public health that much of the popular interest in health matters was evoked before the germ theory of disease and its corollaries became fully developed. As the result of premature generalization the public has warmly espoused a number of wrong conceptions of disease and of ways of preventing disease. To be specific, two instances of this confusion are found in the demand for garbage disposal and plumbing inspection.

Sanitarians do not admit that even a grossly improper method of garbage disposal can have much to do with the spread of disease in a sewered city or that diphtheria or typhoid fever or any other disease is properly attributable to the entrance of sewer air into dwelling houses. So firmly embedded in public belief, however, is the connection of piles of decaying garbage with outbreaks of infectious disease, and of "defective plumbing" with all sorts of maladies that to the average citizen "garbage disposal" and "plumbing inspection" bulk large as the chief if not the only activities of a municipal health department.

In the light of our present knowledge we may well ask what are the actual dangers to health from these two sources? It is now well known to bacteriologists that disease germs do not "breed" in garbage heaps, but that on the contrary if added from outside they speedily die off. The offensive odors of decomposition may be unpleasant and undesirable; there is no evidence that they produce disease or dispose to disease. On the other hand, it may be argued that the existence of heaps of decomposing organic matter tends to maintain or create general habits of uncleanliness which themselves are detrimental in a roundabout way to the health of a community. And again it is known that the house-fly may breed in garbage piles, particularly if horse manure is present, and that under certain conditions this noxious insect may become the bearer of disease germs to food. But when the worst is said it must be admitted that the known danger to health from garbage piles and "dumps" is relatively insignificant compared with the danger from other well-known but less popularly feared sources. Disease does not originate in garbage piles, however offensive they may be; the house-fly, however disgusting and annoying its habits, suffers from no disease transmissible to man, and does not convey disease unless it has access to material in which disease germs are present.

The truth is that garbage disposal in large cities is more a matter of municipal housekeeping than of public health; proper methods of garbage collection and destruction must be urged rather from economic and esthetic considerations than on hygienic grounds. There are of course certain features in the handling of refuse and waste that need hygienic control, just as there are in street cleaning, but the problem is essentially not one of public health. At present in some cities the department of health is burdened with the task of caring for the city waste and its success or failure as a conservator of the public health is too often measured by the frequency with which coal ashes are scattered in alleys or the length of time that decaying vegetable matter remains in tin cans in hot weather.

One thing should be clearly understood by municipal authorities and by the general public, that regular collection and cleanly handling of ashes and table scraps is not one of the surest and most profitable ways of protecting health and preventing disease. Efficient administration of this branch of public work should not be allowed to take the place of measures that directly affect the public health.[4]

Few dangers to health have loomed larger in the public eye than that from "sewer gas." Elaborate and amazingly expensive systems of plumbing are required by law to be installed in every newly erected dwelling house in our large American cities. Plumbing inspection to-day occupies a large part of the working force of many municipal health departments. In Baltimore in 1908, to cite a single instance, this work was carried out by one inspector of plumbing, seven assistant inspectors of plumbing and one drain inspector at a total salary cost of $8,250 or about one-tenth of the total salary appropriation for all public-health work. And yet, if all the most recent and searching investigations such as those of Winslow and others are to be believed, the actual peril to health involved in the entrance of small quantities of sewer air into houses is so small as to be practically negligible. It may be questioned whether plumbing inspection, as ordinarily conducted, can be shown to save a single life or prevent a single case of disease. There is certainly no reason to suppose that any infectious disease is due to germs carried in sewer air. It might reasonably be maintained that slightly leaky gas fixtures are a much more serious menace to the health of house dwellers than defective plumbing. At all events our present knowledge affords small justification for the expenditure of public money to insure that the odor of peppermint does not enter our houses when oil of peppermint is designedly introduced into the house drains.

In the matter of heating and ventilation enormous sums have been spent and are being spent to "renew" the air in rooms and public assembly halls and to introduce "pure air" in what has been assumed to be necessary amounts. And yet if the work of Beu,[5] Heymann, Paul, Erclentz, Flügge,[6] Leonard Hill and others means anything it demonstrates that the whole effect from "bad air" and crowded rooms is due to heat and moisture and not to carbon dioxid or to any poisonous excretions in expired air. When all the effects of "crowd poison" upon a group of individuals in an experimentally sealed chamber can be eliminated by rapidly whirling electric fans it is useless any longer to look upon carbon dioxid as "a measure of danger." If we recognize that all the discomfort from breathing air in a confined space is due to a disturbance of the thermal relations of the body, the problem of ventilation becomes very different from what has usually been supposed. In temperate climates at all events it ought to be much simpler to provide for proper heat regulation of the body than to warm a large volume of outside air and introduce it into a building continuously or at stated intervals. It may well be asked whether the elaborate legal regulations governing the "supply" of air and the cubic feet of bedroom space have a real basis in scientific knowledge. If over-heating, moisture-content and stagnation of the air are the chief things to be avoided, may this end not be reached more effectively and less expensively than by present methods?

One conspicuous function at present required of or voluntarily exercised by health departments is the practice of terminal disinfection after cases of infectious disease. This has come to play a large part in municipal health activities and is responsible for an important share of the expense. In Boston, for example, in 1909, about one-tenth of the annual appropriation was expended for disinfection. One of the most experienced New England city health officers has recently seriously questioned the value of such an expenditure.[7] After a study of the ratios of recurrences in certain diseases he concludes that, "Both theory and facts, so far as any data are available, indicate that terminal disinfection after diphtheria and scarlet fever is of no appreciable value." This view has met with strong support from the experience of a number of English health officials, even if it cannot be regarded as conclusively proved. Every one now knows that the large sums of money spent in measures of disinfection directed against yellow fever gave little return in added safety. We can hardly take for granted that any process of combating disease is effectual simply because it is customary or traditional. It is evident that the whole question of disinfection needs to be studied afresh with a view to actual efficacy. It is not a subject for laboratory experimentation alone, but must be investigated as a problem of practical public health administration.

The importance of control and supervision of the sources of public water-supply has long been recognized, but the importance of controlling the quality of the public milk supply, although frequently urged by sanitarians, is not always appreciated. At the present time in the great majority of American cities it is safe to say that for every case of infectious disease due to drinking-water ten cases are caused by infected milk. It is difficult to secure adequate funds for the sanitary control of the milk supply. By sanitary control of milk is meant not the upholding of a rigorous standard of butter fat and total solids, but the maintenance of proper standards of cleanliness and health for dairy cows and especially the safeguarding the milk from infection during collection and transportation. Under some conditions the protection of the consumer against milk-borne infection may be best brought about by compulsory pasteurization of that portion of the milk supply which cannot otherwise be raised to proper standard. Whatever method of control be adopted, it is certain that any genuine improvement in the character of a milk supply will be followed in the long run by a lessening in the amount of typhoid fever, diphtheria, scarlet fever and to some extent tuberculosis.

One of the important bacteriological advances of the last few years has been the discovery that a considerable number of healthy persons, convalescents or others, harbor disease germs and that these persons are important agents in spreading disease. The detection and proper treatment of disease-germ carriers, particularly in the more serious diseases and before or in the early stages of an epidemic, is now recognized as an important although difficult task. The whole question of the control of germ-carriers is one that needs more careful study with a view to determining the actual results of the methods adopted. From this point of view, inspection of school children, especially at the beginning of the school year, is probably to be classed as a highly profitable activity, although it is to be wished that fuller and better-studied statistics were available.

In rural communities, undoubtedly one of the simplest, as well as most important, health-protective measures is the adoption, under compulsion if need be, of a safeguarded and standardized form of barrel privy.[8] A corollary hardly necessary to mention is the total abolition of the privy in all thickly settled towns. For lack of such regulations soil pollution occurs, the house-fly finds an opportunity to transfer disease germs from excreta to food, and typhoid fever and hookworm disease become constant plagues over wide regions.

Another field in which practical workers are convinced that certain measures have direct efficacy in saving life is that of infant mortality. It has even been said that for the expenditure of a certain sum the saving of a life can be guaranteed. Certain it is, that in few public health activities is the ratio between effort expended and results obtained so clearly seen.

It is impossible at present to apply direct tests

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[1] Condensed from a paper presented before the Congress of Technology, Boston, April 10, 1911, to commemorate the fiftieth anniversary of the granting of the charter to the Massachusetts Institute of Technology. The paper was printed in full in "Science" for June 2, 1911. A briefer paper, touching upon some of the same points, by Dr. H. W. Hill, appears elsewhere in this issue and the same general subject is discussed in our current editorial columns.—Ed.

[2] Professor of Bacteriology, University of Chicago, and Editor, "Journal of Infectious Diseases," Chicago, Ill.

[3] M. N. Baker, in report as Chairman Committee on Municipal Health and Sanitation, National Municipal League, Buffalo, N. Y., 1910.

[4] Any one who fancies that to depreciate garbage disposal as a health measure is flogging a dead horse will be disabused of this impression if he has experience with the beginnings of a typhoid epidemic and learns how often public attention is diverted from significant issues like water-supply, milk-supply, and contact, by appeals to the prejudice against slovenly ways of handling harmless household refuse.

[5] Zeitschr. f. Hyg., 1893, 14, p. 64.

[6] Zeitschr. f. Hyg., 1905, 49, p. 363.

[7] Chapin, "Jour. Amer. Public Health Assoc.," 1911, 1, p. 32.

[8] See Public Health Reports for 1910, published by the Public Health and Marine Hospital Service, articles by Stiles and Gardner, and Lumsden, Roberts and Stiles.

of efficiency to some measures that undoubtedly promote health. The influence of playgrounds, public baths, regulation of the hours of labor in extra-arduous industries and the like is real if it cannot be accurately determined or estimated. Certain activities of a health department may be worth continuing for their educational value, although their direct utility may be questioned. Many topics need investigation in order to discover their real bearing upon the public health. Among these are such matters as the effect of a smoky atmosphere, the alleged nervous strain due to city noise and numerous important questions in the domain of food adulteration and contamination. Premature and drastic action by health authorities in matters concerning which there is profound disagreement among experts may cast discredit on other lines of activity in which there is and can be no difference of opinion.

For the present it seems worth while to emphasize more sharply than heretofore the distinction between public health measures of proved value and those that owe their existence to tradition or to misdirected and uninformed enthusiasm. Further study of the results obtained by certain of the usual and conventional health department activities is also much needed, and as a preliminary to such study the proper collection and handling of vital statistics is essential. It is poor management and unscientific procedure to continue to work blindly in matters pertaining to the public health, to employ measures of whose real efficiency we are ignorant and even to refrain from collecting facts that might throw light upon their efficiency.

A New Drag-Line Scraper Bucket.

A scraper bucket differing in many important respects from those commonly used with drag-line excavators has been tested in severe service for more than 18 months on the New York aqueduct work. This bucket is distinguished by the absence of rigid bales, the unobstructed open end or mouth and particularly by the adjustability of the hauling connections. This last feature permits the easy adjustment of the bucket to the best cutting angle for any material being excavated.

The bucket is supported, hauled and dumped through a system of chain bridles shown in Fig. 1. By the use of chains only, without any rigid bales such as are commonly used, the bucket is made less liable to damage under hard usage. It can be dropped in any position without an accident, such as the bending of a bale, which might occur when bales are used. Stud-link chain is used for the bridles, as it was found that with open links the chain would often foul or bunch up when the bucket was picked up after a drop.

There are three separate bridles or pairs of chains—the hoisting bridle, dump control bridle and pulling bridle. The chains of the hoisting bridle are attached at one end to the hoisting cable and at the other to bearing pins projecting from the sides of the bucket. The bearing pins are protected by cast-steel hoods, open at the top and rear. The two chains are held apart by a spreader-bar above the bucket to prevent their pinching against its sides and interfering with the dumping movement. The bearing pins are placed enough to the rear of the center of gravity of the loaded bucket to give a strong dumping tendency when the controlling bridle is released.

The controlling-bridle chains are in two sections joining each other where they are both attached to large rings sliding on rods along the upper edges of the bucket. The upper section of the bridle is attached by a shackle to an adjuster bar secured to the hoisting cable. The lower section is attached to the pulling cable or drag line. While the bucket is being hoisted, after having been filled, the drag line is kept taut so that the sliding rings are held at the forward end of their slides until the bucket has been brought to the dumping place. The pulling cable is then slacked, releasing the controlling bridle and thus allowing the rings to slide back along the guide bars and drop the forward end of the bucket. Fig. 2 shows the bucket in the dumping position. By means of the adjuster bar at the upper end of the controlling bridle, the length of the upper section of the bridle can be regulated to give the proper tilt to the bucket when loaded with any given material.

The pulling bridle is attached at one end to the drag line and at the other to lugs on the forward end of the bucket. The pulling lugs are of manganese steel riveted, or bolted if desired, to the cutting edge of the bucket so that they can be removed and replaced if worn out. The pulling bridle is assisted in its work of dragging the bucket by the lower section of the controlling bridle, whose attachment to the pulling cable is made through shackles and adjuster bars, as shown in Fig. 1.

When digging in soft material, such as loose soil or sand, the pulling section of the control bridle is lengthened by moving its shackles back along the adjuster bar to the last hole. The pull of the drag line then comes directly on the pulling bridle, and since the pulling lugs are well down toward the bottom of the bucket it will lie flat in the material without tendency to dig into it too deeply. But when harder material is encountered, the controlling bridle is shortened so that it takes a part of the pull, or nearly all the pull if desired. Since this bridle is attached at the top of the bucket, the result is to drag the bucket in an inclined position so that its teeth are forced down strongly into the material. In this way the bucket can be made to fill to full capacity in "rotten rock," handled without blasting.

This method of adjustment is obviously more convenient than that of fitting wedge-shaped pieces to the bottom of the bucket to keep the back up and cutting edge down in hard material. The length of the control bridle can be changed in about three minutes, and with a little experimenting the best cutting angle for the material at hand can soon be found.

Another adjustment is provided for side-cutting by means of a three-cornered steel casting which serves as a link between the drag line and the ends of the pulling-bridle chains. Normally the drag line is attached at a hole in one corner of this triangular casting while the two chains of the bridle are attached respectively at holes in the two other corners. For side cuts, the drag line is attached at the same corner with one chain of the bridle. This gives the effect of having one bridle chain longer than the other and thus produces the tendency to side cut.

As can be seen in Fig. 1, there is no brace nor hood over the front end of the bucket and this feature, it is claimed, enables the bucket to take a larger load. In top soil, loads of 2 cu. yds. have been taken in a 1½-yd. bucket, and this load was dug by the bucket while moving less than twice its own length.

The sides of the bucket are not at right angles to the bottom but are inclined inward, approaching each other at the top. This shape, it is claimed, protects the side plates and hoist-bridle bearing pins from excessive wear, since the furrow cut by the shoe is wider than the upper part of the bucket.

This bucket has just been put on the market by the Hayward Co., of 50 Church St., New York City, to whom we are indebted for the information for this description. The first bucket made has been practically worn out in tests after handling about 20,000 cu. yds. of material. This bucket, however, was of lighter material and inferior design to the second model which is the one now being built. A bucket of this second design has handled between 16,000 and 18,000 cu. yds. of material and at the present time shows practically no wear.

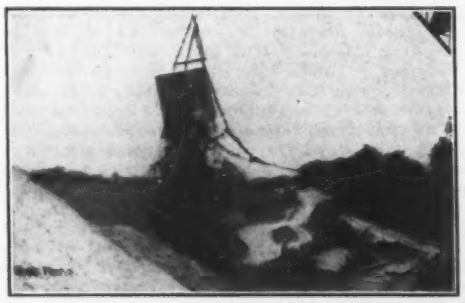

Fig. 2. Hayward Scraper Bucket in Dumping Position.

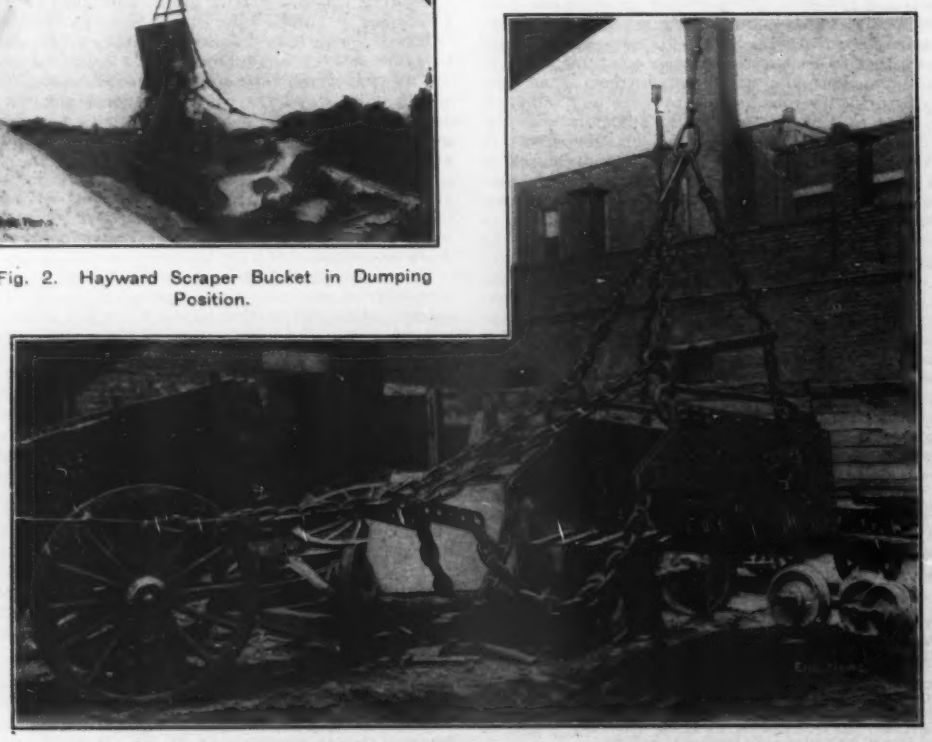

FIG. 1. THE NEW HAYWARD DRAG SCRAPER BUCKET: HOISTING POSITION.

Wet Magnetic Separation for weakly magnetic ores is carried out in Europe by the Ullrich separator, built in Germany, according to an article in "Stahl und Eisen" of July 13, 1911. A number of pole-pieces project vertically from an electro-magnet, and are arranged in a circular group. Over each pole-piece is an inclined trough, which receives material at its outer edge and discharges it into a central waste-hopper. Over the circle of troughs is a ring-shaped armature, whose lower edge is tapered to a knife-edge, or rather a group of several concentric rings of this shape. These armature rings rotate, picking up the magnetic material from the troughs and depositing it between the magnet-poles in pockets which alternate with the supply troughs. The several armature rings can be adjusted vertically independent of each other, and thereby give a magnetic field of any desired gradation of intensity. Machines of this kind were used successfully to concentrate iron ores at the plant of the Dunderland Iron Ore Co., in Norway, where the hematite ore carrying some magnetite, in a gangue of apatite, quartz and mica, could not be handled by dry magnetic separation. Trials of concentration with the Ullrich machine, however, gave concentrates of 64 to 66% iron from ores of 27 to 37% iron, and 76 to 82% of the total iron content of the ore was saved, and the concentrate was remarkably low in phosphorus.

An External Throttle Valve for Locomotives.

The usual arrangement of locomotive throttle valve inside the dome of the boiler, with its operating rod and levers inside the boiler shell has well known disadvantages in regard to accessibility for adjustment and repair, but the arrangement is practically universal. A throttle valve located outside the boiler shell, therefore, is a decided novelty in locomotive design. Such a device has been invented and patented by Mr. W. L. Buck, Superintendent of Motive Power of the Atchison, Topeka & Santa Fe Ry., and is illustrated herewith.

As shown, the throttle is located outside the boiler shell underneath the front end as near to the cylinders as other construction details permit. The throttle valve itself is of the balanced double-poppet type universally used on American locomotives. It is operated by a long reach rod from the cab with the operating handle convenient to the engine runner's seat.

This throttle was designed primarily for use with locomotives equipped with superheaters, and it is doubtful whether it could be successfully used on an ordinary locomotive using saturated steam as condensation would collect above the valve whenever the throttle was closed. In the drawing, Fig. 1, it is shown as applied to a locomotive equipped with the Buck-Jacobs superheater.* This superheater consists of a steam drum, the shell of which is contiguous with the shell of the boiler. The superheater heads are riveted to the shell, and form tube sheets for a set of fire tubes through which pass the gases and products of combustion.

The throttle is secured beneath the superheater on the outside of the boiler shell. Communication with the superheater is by means of a hole through the shell. Above the superheater is a connection to a large globe valve, and this, in turn, is connected to the steam dome by an outside pipe. Short steam pipes lead from the throttle to the cylinder saddle casting.

The details of the throttle valve with its casing and connections are shown in Fig. 2. The throttle is supported by a cast-steel saddle, riveted through its upper flange to the boiler shell. The throttle box is bolted to the lower flange of this saddle, a steam tight joint between the box and saddle being made by the usual form of joint ring.

The device may be applied also in connection with any design of smoke-tube superheater. In such case saturated steam may be led to the superheater header either by an external pipe from the dome, or by the usual inside dry pipe. From the header, superheated steam is led to the throttle by two steam pipes, similar to the common form of smokebox steam pipe.

The external throttle is readily accessible at all times for inspection and repair. The joints on the pipes leading to and from it are outside of the boiler shell, where steam leaks may be quickly detected and where repairs may be made conveniently.

By closing the globe valve near the dome, steam may be shut off from both the throttle and the superheater. Repairs to these parts may then be made without the long delay incident to blowing off steam, cooling the boiler, and removing the dome cap, necessary with the ordinary internal throttle. It may also be noted that there is no stuffing box, gland or packing for the throttle rod in the cab, and one possible source of leaking steam there is avoided.

With the external throttle, superheaters are always filled with dry steam ready for delivery direct to the cylinders. Maintaining steam continually in the superheater provides still further advantage in protecting the superheater and joints from the effect of hot gases.

*Engineering News, Jan. 27 and June 2, 1910.

A Coal-Mine Fire-Fighting Car has been put into use at two of the collieries of the Mahonoy and Schuylkill division of the Lehigh Valley Coal Co. The need of such a car was suggested by the difficulty experienced on several occasions in fighting breast fires at Packer No. 5 colliery in a vein rich in gas. The pitch of the vein was about 60° and it was a hard matter to fight the fire by the old method of carrying water up this slope in powder kegs.

The new car, as described in the September, 1911, issue of "Mines and Minerals," consists of a truck with a flat floor upon which is mounted a 4 × 5-in. horizontal triplex electric-driven pump with a capacity of 80 gals. per min. The truck also carries 2,000 ft. of insulated wire, two 3-gal. fire extinguishers, 400 ft. of 1-in. rubber hose, 50 ft. of 3-in. tail pipe and a hatchet, axe and saw. The car is kept on the surface in a fireproof building and can be lowered to any lift of the mines within three minutes after an alarm has been given.

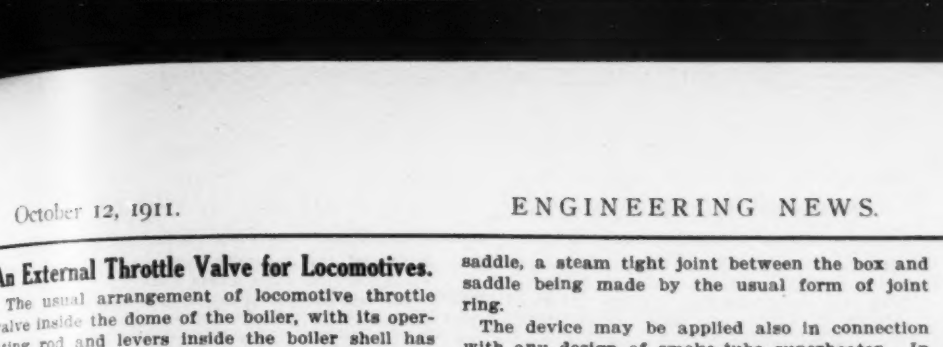

FIG. 1. LOCOMOTIVE EQUIPPED WITH THE BUCK EXTERNAL THROTTLE VALVE; ATCHISON, TOPEKA & SANTA FE RY.
W. F. Buck, Superintendent of Motive Power, Inventor.

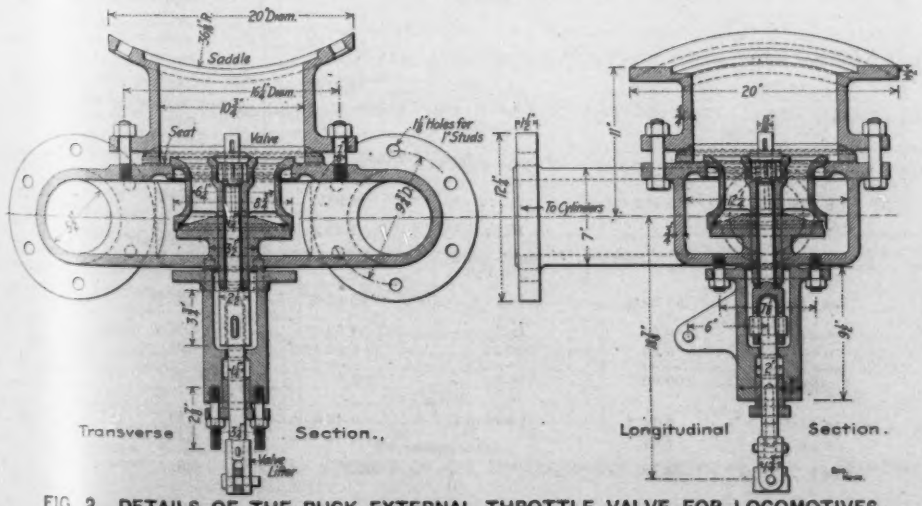

FIG. 2. DETAILS OF THE BUCK EXTERNAL THROTTLE VALVE FOR LOCOMOTIVES.

The Paving and the Care of Streets.*

By EDWIN A. FISHER,† M. Am. Soc. C. E.

GUARANTY.—Much has been said and written upon the subject of pavement guarantees. A few years ago a long guaranty was thought to be the one thing needful in street paving. New York City laid many pavements under a 15-year guaranty period. Many other cities, unless prevented by charters, exacted ten years. Of late, however a reaction has set in and many engineers and other municipal officers argue that the guaranty should be abolished entirely. I believe that some guaranty is essential but that it should not cover an extended maintenance but be limited generally to the material and workmanship.

Where a large amount of underground work is done, scattered, as is usual, over a considerable distance, it is absolutely impossible, with ordinary inspection, to know that the trenches are properly backfilled. The contractor should be responsible for this work.

We have fixed the guaranty period for standard pavements at five years, and for resurfaced streets and sidewalks at three years. I do not think a uniform length of guaranty of all kinds of pavements is right. It ought to be only long enough to detect defects of material and construction and should vary with the different kinds of pavements, and other conditions. I recently told a committee of citizens that any contractor who would sign a contract with a maintenance guaranty for a macadam pavement on a street of considerable traffic ought to be sent to a lunatic asylum.

CONTRACTS.—Two methods of letting contracts are practiced: the lump-sum bid and the unit-price bid. If the exact quantity and character of the work can be fully and clearly described, and changes are not probable, the lump sum is the most satisfactory. On the other hand, as is usual in the case of a permanent pavement, especially in the older portion of the city where many of the quantities are not positively known, the unit-price method is preferable. I have used this method altogether for pavements. What is wanted is a method that will eliminate the gambling element and enable the engineer to pay the contractor a fair price for satisfactory work. Care should be exercised, however, in making up the bidding sheets, that the estimated quantities correspond as nearly as possible with the actual, else you will get unbalanced bids. I have found it better, in the case of items where the quantity was uncertain, to fix the price in advance, or leave it out altogether, and treat such items as extra work, rather than to put in estimated quantities which might vary materially from the actual, and thus tempt the contractors to make unbalanced bids.

LOWEST BIDDER.—The charter provision compelling the letting of all contracts for public work to the lowest bidder that will furnish adequate security results, in many cases, in turning over municipal work requiring special knowledge and skill to ignorant or inexperienced men, deficient in every quality required for the successful execution of the work. Nothing has so tended to bring the business of municipal contracting into disrepute as the lowest bidder. From a large experience in both public and private work, I am clearly of the opinion that the contracting board should have discretion to let contracts as in its judgment is for the best interests of the municipality. In nearly all cases the lowest bidder would get the work. Honesty, ability, intelligence and special knowledge would be recognized, and the business of city contracting be placed on a higher plane. The work would also be better and more economically done.

For 25 years prior to the year 1900 municipal contracts for the City of Rochester were let by an elected board of three members having authority to award contracts as in its judgment was for the best interests of the city. While this board, on account of its large powers, was made the central figure in every municipal campaign, and all sorts of criticism and abuse heaped upon its members during the heat of a campaign, I do not recall that its acts, with respect to the letting contracts, were ever questioned.

BITULITHIC.—Mention may be made of the bitulithic pavement that has come rapidly and extensively into use in the last ten years. This pavement is correct in theory, and its extensive and generally satisfactory use indicates that its theory is sustained by actual practice. It combines very many of the qualities of an ideal pavement. Its success, however, depends, more than any other kind, upon extreme care in the selection and grading of the materials, and in

*From an address before the Williamsport Board of Trade, June 12, 1911.
†City Engineer, Rochester, N. Y.

the proper execution of the work. It is therefore perhaps an actual advantage that its use is covered by broad patents, preventing its construction except under the skilled supervision of the patentees.

STREET RAILWAY TRACK.—Two methods of construction are followed: Wooden tie construction, consisting of a concrete foundation 12 ins. thick, extending the entire width of the space, between lines drawn 6 ins. outside the outside ends of the ties, put in at the same time and connected with the 6-in. foundation outside. Wooden ties about 30 ins. c. to c. are left embedded in this concrete. This form is favored in streets where recent excavations have been made under the track space.

The other method, and one now practiced, is the use of steel ties of 3 ins. depth, spaced 4 ft. c. to c., embedded in a 12-in. Portland cement concrete foundation extending entirely across the space between lines drawn 6 ins. outside the ends of the ties and connected with the 6-in. foundation under the pavement. Old rails have been used for ties in some streets.

Some of the Properties of Oil-Mixed Portland Cement Mortar and Concrete *

By LOGAN WALLER PAGE,† M. Am. Soc. C. E.

In October, 1909, the writer found that oil in considerable quantities could be combined with wet Portland cement paste by a simple mixing process. It was noted that when oil was added to wet cement it disappeared completely when mixed for a few moments, and, furthermore, that there was no apparent separation of the ingredients upon setting. Experiments were at once begun with various kinds of oil, to ascertain which was best adapted for the mixture. After these preliminary inquiries were complete, the following tests were conducted, or are now in progress, in order to investigate the properties of oil-mixed cement, mortar and concrete:

(1) The tensile strength of neat cement and 1:3 mortar;
(2) The time of setting;
(3) The crushing strength of mortar and concrete;
(4) Impact tests on concrete;
(5) The modulus of elasticity of concrete;
(6) The absorption of concrete;
(7) The permeability of concrete;
(8) Bond tests;
(9) The density of concrete.

Some of these tests are in an incomplete state; others are contemplated, in an effort to develop those phases of the material which give most promise of practical results. The writer's excuse for publishing them in such an incomplete state is that, with his limited facilities for testing, it would require considerable time to complete the work, and, in view of the results already obtained, it seemed likely that engineers with better facilities would hasten the work through its experimental stage.

MATERIALS.—The materials used consisted of Portland cement, river sand, and ¾-in. crusher-run gneiss. Analyses of the several oils selected for use are given in Table I. The cement complied with the specifications recommended by the Special Committee on Concrete and Reinforced Concrete. Mechanical analyses, typical of the sand and stone used, are given in Table II.

The sand contained 37% of voids, the stone 43%.

METHOD OF MIXING CONCRETE.—The weights per cubic foot of the dry sand and stone were determined, the materials being loosely shaken in a measure containing 1 cu. ft. The weight of cement was assumed to be 95 lbs. per cu. ft. The percentage of moisture in the sand and stone was determined every day that a concrete mixture was made, and the proportions of sand and stone in the mixture were corrected for the moisture content. All concrete was proportioned by volume, but the materials were measured by weight. In all the cases the percentage of oil used is based on the weight of the cement in the mixture.

The following method of mixing was used: The proper quantities of cement and sand were mixed dry until of uniform color. Water was then added and the mass was turned as often as was necessary to produce a rather wet mortar. The water added to the mortar was not weighed, the appearance of the mix being the criterion for determining the proper quantity. In general, however, the total quantity of water, including that in the sand, was about 17% of the total weight of the cement and sand. After having mixed the mortar, the desired quantity of oil was added, and the mass was turned over as many times as was necessary to break up the oil and incorporate it thoroughly with the other ingredients. The previously moistened stone and the oil-cement mortar was then combined and turned until thoroughly mixed. The percentage of water required to make a rather soft mixture was determined from the appearance of the first batch, and every batch of the same proportions made thereafter contained the same gross quantity of water.

All mortar compression test pieces were proportioned by weight, the sand being thoroughly dry; 19.5% of water was used in the mix.

TABLE II.—MECHANICAL ANALYSES OF SAND AND STONE.

Sand		Stone	
Sieve.	Percentage retained.	Sieve.	Percentage retained.
¼-in.	3	¾-in.	28.4
⅛-in	11	½-in.	66.3
No. 10	17	¼-in.	92.1
No. 20	42	⅛-in.	98.4
No. 30	66		
No. 40	87		
No. 50	93		
No. 80	96		
No. 100	99		

1:3 MORTAR.—Tests made on 1:3 mortar containing oil show that the tensile strength is influenced very little by the oils at 7 days, 28 days, or 6 months, and furthermore, there is a decided gain in strength at 28 days and 6 months over that at 7 days. The strength of oil-mixed mortars is given in Table III, and plotted on Fig. 1.

TABLE III.—TENSILE STRENGTH OF 1:4 MORTAR, OTTAWA SAND.

Percentage of oil.	Oil No. 4,923. 7 days.	28 days.	6 mos.	Oil No. 5,053. 7 days.	28 days.	Oil No. 4,981. 7 days.	28 days.
0	256	296	326	244	331	283	367
2½	299	400	449	297	353	259	327
5	287	316	372	313	334	268	341
10	252	331	360	304	371	264	329

TIME OF SETTING.—The addition of oil retards both the initial and final set. Quantitative results of tests with the Gillmore needles on specimens subjected to identical conditions are given in Table IV, and are shown graphically on Fig. 2. The effect of 10% of oil is to increase the time of initial set about 90%, and the time of final set about 60%.

TABLE IV.—THE EFFECT OF OIL ON THE TIME OF SETTING OF PORTLAND CEMENT. Oil No. 4,923.

Percentage of oil	0	2½	5	10
Initial set	1 h. 18 m.	1 h. 31 m.	1 h. 57 m.	2 h. 27 m.
Final set	3 h. 43 m.	4 h. 56 m.	5 h. 27 m.	5 h. 57 m.

CRUSHING STRENGTH.—Specimens of mortar and concrete were molded in cylindrical forms, 6 ins. in diameter and 6 ins. high. The materials were deposited in the molds in layers about 2 ins. thick, and were troweled and tamped. The molds were removed after one day, but the specimens were not disturbed until the second day after molding. Air-cured specimens were kept moistened for seven days after molding. All tests were made in a universal machine having a capacity of 200,000 lbs. The bearing surfaces of all mortar specimens were bedded in several thicknesses of blotting paper. It was found necessary to bed the top surface of each concrete specimen in plaster of Paris before testing, blotting paper

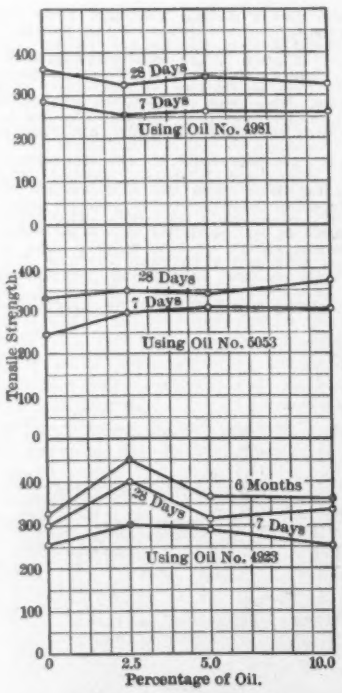

Fig. 1. Tensile Strength of 1:3 Mortar Briquettes.

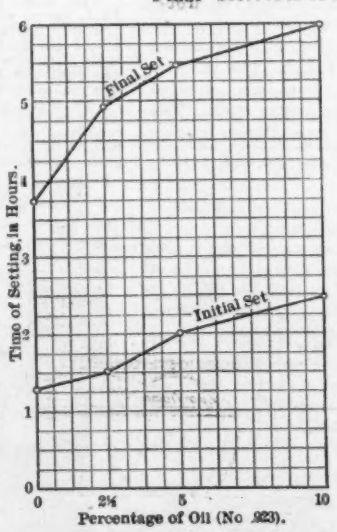

Fig. 2. Effect of Oil on Time of Setting of Portland Cement.

*Paper presented before the American Society of Civil Engineers, Nov. 1, 1911. Published in Proceedings of the American Society of Civil Engineers, September, 1911, p. 993.

†Director, Office of Public Roads, U. S. Dept. of Agriculture.

TABLE I.—ANALYSIS OF OILS USED IN CEMENT-CONCRETE MIXTURES.

Sample number	4,145	4,146	4,147	4,149	4,170	4,923	4,981	5,053
Type	Fluid Residual Oil.	Fluid Residual Oil.	Fluid Residual Oil.	Fluid Residual Oil.	Cut-back Oil Asphalt.	Fluid Residual Oil.	Fluid Residual Oil.	Fluid Residual Oil.
Character	Fluid, greasy.	Fluid, greasy.	Fluid, greasy.	Fluid, greasy.	Fluid, sticky.	Fluid, greasy.	Fluid, slightly sticky.	Fluid, slightly sticky.
Specific gravity at 25°/25° cent.	0.924	0.910	0.926	0.923	.....	0.945	0.893	0.924
Loss at 163° cent., 5 hours, 20 grammes.	6.86%	12.56%	7.98%	7.02%	18.38%	1.35%	27.17%	3.70%
Character of residue	Fluid, greasy.	Fluid, greasy.	Fluid, greasy.	Fluid, greasy.	Semi-solid, sticky.	Fluid, greasy.	Slightly granular more viscous than original.	Fluid; granular in appearance.
Soluble in CS_2, air temperature	99.99%	99.99%	99.93%	99.95%	99.81%	99.96%	99.95%	99.90%
Organic matter insoluble	0.01	0.01	0.07	0.05	0.13	0.04	0.02	0.07
Inorganic matter insoluble	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.03
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Percentage of total bitumen insoluble in 86° paraffin naphtha	2.23%	6.82%	10.16%	2.24%	16.87%	3.46%	1.00%	4.12%
Fixed carbon	2.41	3.36	5.11	1.98	.....	4.18	1.77	2.83
Specific viscosity, Engler 50° cent.	14.2	6.4	18.2	10.2	.....	65.1	2.5	17.4

TABLE V.—TESTS OF OIL-MORTAR AND OIL-CONCRETE CYLINDERS.

Crushing Strength, in pounds per square inch.
All 1:3 mortar (by weight) except specimens 6c to 18c.
Specimens 6c to 12c are of 1:3:6 Concrete; Specimens 13c to 18c are of 1:3:5 Concrete (by volume).
The numbers in parentheses indicate the number of specimens tested.

Mark.	Percentage of oil.	Character of oil.	Stored in air.			Stored in water.		
			28 days.	6 months.	1 year.	28 days.	6 months.	1 year.
No.	0		1 170 (5)	1 300 (2)	1 597 (2)	2 135 (6)	2 275 (2)	2 308 (2)
1	5	Fluid Residual Oil No. 4 145	1 030 (2)	890 (2)	1 220 (2)	1 715 (2)	2 160 (2)	2 240 (2)
17	10	" " " " "	790 (1)			1 320 (1)		
2	15	" " " " "	895 (2)	780 (2)	880 (2)	1 290 (2)	1 615 (2)	1 700 (2)
18	20	" " " " "	775 (2)	910 (2)	1 125 (2)	1 000 (2)	1 420 (2)	1 425 (2)
3	30	Fluid Residual Oil No. 4 146	915 (2)		1 110 (2)	1 770 (2)		2 560 (2)
4	5	" " " " "	830 (1)			2 400 (2)		
19	10	" " " " "	1 315 (2)	1 275 (2)	1 670 (2)	1 775 (3)	2 410 (2)	2 475 (2)
5	15	" " " " "	935 (2)	1 295 (2)	1 280 (2)	1 945 (3)	1 640 (2)	1 790 (2)
20	20	Fluid Residual Oil No. 4 147	1 405 (2)	1 155 (2)	1 715 (2)	1 995 (2)	2 475 (2)	2 700 (2)
6	5	" " " " "	1 070 (1)			1 720 (1)		
21	10	" " " " "	975 (3)	1 085 (2)	1 435 (1)	1 670 (2)	2 250 (2)	2 250 (1)
7	15	" " " " "	795 (2)	1 055 (2)	1 310 (2)	1 400 (2)	2 010 (2)	1 895 (2)
22	20	Fluid Residual Oil No. 4 149	1 395 (2)	1 105 (2)	1 395 (2)	2 220 (2)	2 655 (2)	2 460 (1)
23	5	" " " " "	1 170 (1)			1 750 (1)		
8	10	" " " " "	1 440 (2)	1 395 (2)	1 390 (2)	1 895 (2)	2 315 (2)	2 220 (2)
24	15	" " " " "	995 (2)	1 085 (2)	1 125 (2)	1 230 (2)	1 475 (2)	1 530 (2)
25	20	Cut-back Oil Asphalt No. 4 170	1 010 (2)	940 (2)	1 315 (2)	1 700 (2)	2 055 (2)	2 345 (1)
9	5	" " " " "	980 (2)	1 005 (2)	1 510 (2)	1 680 (2)	1 825 (2)	2 200 (1)
10	10	" " " " "	1 055 (2)	1 170 (2)	1 555 (2)	1 295 (2)	1 365 (2)	1 695 (1)
11	15	" " " " "	890 (2)	1 230 (2)	1 325 (2)	1 175 (2)	1 340 (2)	1 375 (1)
12	20		1 000 (3)			1 370 (2)		
6c	0		750 (2)			1 358 (3)		
7c	2½	Fluid Residual Oil No. 4 923	711 (2)			1 142 (2)		
8c	5	" " " " "	656 (2)			961 (3)		
9c	10	" " " " "	542 (2)			750 (2)		
10c	15	" " " " "	605 (3)			620 (3)		
12c	25		920 (2)			1 342 (3)		
13c	0		787 (2)			1 250 (2)		
14c	2½	Fluid Residual Oil No. 4 923	720 (2)			1 092 (2)		
15c	5	" " " " "	698 (2)			1 040 (2)		
16c	10	" " " " "	698 (2)			1 040 (2)		
17c	15	" " " " "	572 (2)			904 (2)		
18c	20							

being used in addition to this bedding. The specimens were crushed at a speed of 0.152-in. per min., and the crushing load was taken at the drop of the scale beam.

The numerical results of the crushing tests are given in Table V, and are plotted on Figs. 3 and 4. As would be expected with an inert substance like oil, the crushing strength decreases in general with increasing quantities of oil. In the case of the oil-mixed mortars, in only one instance is there a serious decrease of strength with the addition of oil up to 10%, namely, that in which oil No. 4145 was used. At 28 days water-cured mortar specimens containing 10% of oil are at least 80% as strong as the plain mortar specimens. In every instance there is a substantial gain in strength at six months over that at 28 days; this is equally true of the one-year specimens. Specimens cured in air are somewhat erratic in behavior. In some instances a considerable gain in strength occurs, in others, a noticeable decrease.

Concrete, like mortar, when mixed with oil, shows a decrease in strength, that containing 10% of oil having roughly 75% of the strength of plain concrete when stored in water. Air-cured concrete, mixed in proportions of 1:3:6 and 1:3:5, containing 10% of oil, has 65 and 75%, respectively, of the strength of the plain concrete mixtures. At the completion of the one-year tests on compression, a marked increase in strength is shown over similar tests at six months. The next tests will be made at the expiration of two years.

TOUGHNESS. — Cylinders of concrete, 6 ins. in diameter and 6 ins. high, were tested in the Page impact machine under the blows of a 10-kg. hammer, falling upon a 5-kg. plunger from successively increasing heights of 1 cm. The height of the last blow, causing rupture, corresponds to the number of blows. The end of the plunger in contact with the test pieces is spherical in shape, with a radius of 3 cm. The specimens were set in plaster of Paris on a piece of plate glass, and after the plaster had hardened they were mounted in the impact machine, the bedded end on the anvil. The results of this test indicate that the toughness or resistance to impact of oil-mixed concrete differs but slightly from that of plain concrete. The impact tests were made on only one specimen from each mix. Failure was indicated by the development of radial cracks, of which there were sometimes two and as often three. The numerical results of the impact tests are given in Table VI.

TABLE VI.—NUMBER OF BLOWS REQUIRED TO PRODUCE FAILURE.

Percentage of oil, No. 4923.	1:3:5 Concrete. Air-cured.	1:3:5 Concrete. Water-cured.	1:3:6 Concrete. Air-cured	1:3:6 Concrete. Water-cured.
0	18	15	15	21
2½	15	33	14	18
5	23	23	15	20
10	13	20	12	21
15	14	20	13	16
20	10	22	..	..
25	..	..	15	16

MODULUS OF ELASTICITY.—Tests for the modulus of elasticity were made on specimens of the usual size, 8 ins. in diameter and 16 ins. high. The deformations were measured with a double micrometer compressometer. The specimens were carefully bedded in plaster of Paris, a spherical bearing block being interposed between the top of the specimen and the moving head of the machine. Loads were applied in two 500-lb. and 5,000-lb. increments, and were released to the initial load of 500 lbs. after each increment of 5,000 lbs., thus permitting of the determination of the amount of permanent set.

Typical stress-deformation and permanent-set curves are shown in Figs. 5 and 6. The values of the initial modulus of elasticity are given in Table VII.

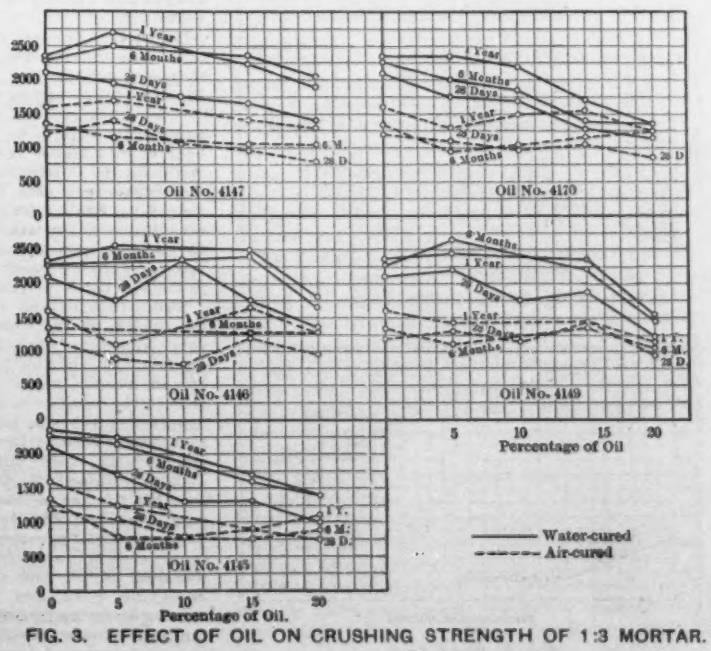

FIG. 3. EFFECT OF OIL ON CRUSHING STRENGTH OF 1:3 MORTAR.

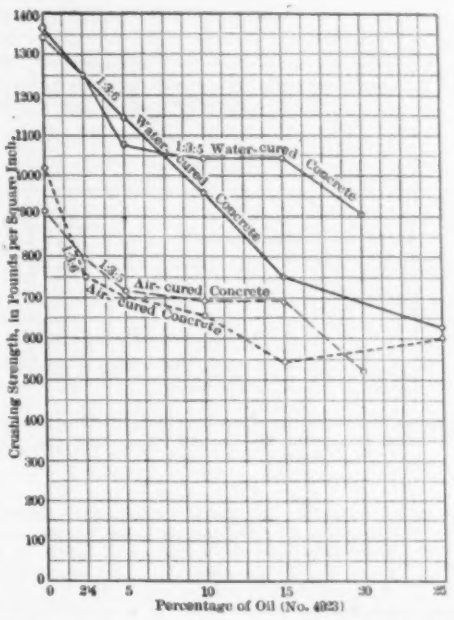
1:3:5 Water-cured Concrete
1:3:6 Water-cured Concrete
1:3:5 Air-cured Concrete
1:3:6 Air-cured Concrete
Crushing Strength, in Pounds per Square Inch
Percentage of Oil (No. 4923)

Fig. 4. Effect of Oil on the Crushing Strength of 1:3:5 and 1:3:6 Concrete (Age 28 Days).

TABLE VII—INITIAL MODULUS OF ELASTICITY—AGE, 28 DAYS.

Percentage of oil, No. 4923.	1:3:5 Concrete. Air-cured.	1:3:5 Concrete. Water-cured.	1:3:6 Concrete. Air-cured.	1:3:6 Concrete. Water-cured.
0	1,300,000	2,550,000	1,300,000	2,200,000
2½	1,350,000	2,700,000	1,000,000	2,400,000
5	1,250,000	2,350,000	850,000	1,900,000
10	1,700,000	3,950,000	1,150,000	1,900,000
15	1,300,000	2,500,000	730,000	2,050,000
20	1,400,000	3,000,000	.....	.....
25	.....	.....	1,400,000	1,950,000

The results in Table VII indicate that the addition of oil to concrete has very little effect on its stiffness, the initial modulus of elasticity, with a few exceptions, showing but little change. The effect of storing in water is to increase the modulus of elasticity to more than that of air-cured specimens, and is as true with oil as without it.

PERMANENT SET.—In the endeavor to discover the effect of oil on the elasticity of concrete, micrometer readings of permanent set were taken after releasing the load to its initial value of 500 lbs. In 1:3:5 concrete, containing as much as 10% of oil, the permanent deformation existing after the application of 500 lbs. per sq. in. was less than that in the specimen containing no oil. This was true of both air-cured and water-cured specimens. The elasticity of 1:3:6 concrete appears to suffer with the addition of oil, the permanent set of the 10% oil mixture, air-cured, being 0.00076 in. per inch of length, as against 0.00019 in. for the plain concrete specimens. The corresponding ratio appears to exist for the water-cured specimens. The permanent set of the 10% oil mixture was 0.00017 in. after the application of 500 lbs. per sq. in. Here, again, the beneficial effect of storing in water is well marked, the permanent set being very small for water-cured concrete, when compared with that cured in air.

ABSORPTION.—In order to determine the water-proofing qualities of oil-mixed concrete, compared with those of a plain mixture, absorption tests were made on 1:3:6 concrete cylinders, 6 ins. in diameter and 6 ins. high. The cylinders were dried to constant weight in an oven, after being cured for 15 days in air. They were then completely immersed in water, and were weighed every day until they had attained constant weight. The results of these tests are plotted in Fig. 7. It will be noted that the addition of oil decreases greatly the percentage of absorption, the cylinder containing 10% of oil absorbing but 1.7% of water, based on the dry weight, while 6.25% was absorbed by the cylinder containing no oil. In almost every case the maximum absorption was attained within one day after immersion, and, furthermore, the rate of absorption seemed to be inversely dependent on the quantity of oil added. It will be noted that there is approximately only 0.5% difference between the absorption of the cylinders containing, respectively, 10 and 25% of oil. The inference to be drawn from this fact is that 10% of oil is nearly as effective as 25%, as far as waterproofing is concerned.

Four vessels of 1:3 mortar, each 2½ ins. high,

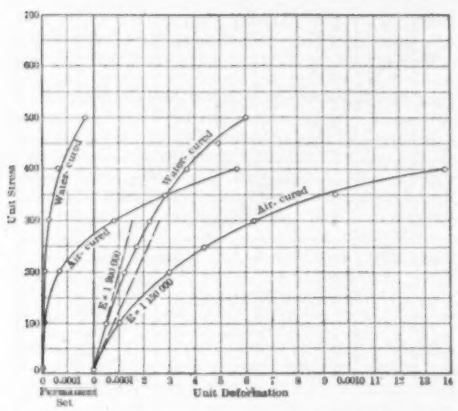

Fig. 5. Stress-Strain Curves 1:3:6 Oil-Mixed Concrete (Mark No. 9, Age 28 Days, 10% Oil, No. 4923).

about ½-in. thick, and having an outside diameter of 8 ins., after hardening in moist air for one week, were immersed in water to a depth of 5 cm. Vessel No. 1 was made with no admixture of oil. A damp spot appeared inside about 1 min. after immersion. In one hour it was completely water-soaked, the moisture having climbed by capillarity above the level of the surrounding water. Within a few days after immersion, water had penetrated the plain mortar vessel until its level inside was the same as that outside. Vessels Nos. 2, 3 and 4 contained, respectively, 5, 10 and 20% of oil. After an immersion of six months, the interiors of the oil-mixed vessels are as dry as they were on the day they were placed in the water. A corresponding series of tests was made on mortar vessels, made to contain water, with like results. The plain mortar vessel leaked, and those of oil-mixed mortar were perfectly tight. These results show with certainty the waterproofing qualities of oil-mixed mortar and concrete.

PERMEABILITY.—The following tests were made on specimens of 1:3 mortar, 3 ins. thick and 6 ins. in diameter. Plain 1:3 mortar, at the age of 28 days, under a pressure of 30 lbs., showed dampness in about ½ hour. Under a pressure of 40 lbs., applied for 24 hours, the leakage amounted to 146 cu. cm. Specimens of the same mixture, but containing 5 and 10% of oil No. 4923, remained perfectly dry for 24 hours, under a pressure of 40 lbs.

A ½-in. coat of 1:3 mortar, containing 10% of oil No. 4923 applied to the surface of a very porous concrete, was absolutely effective in preventing all leakage, even under comparatively high pressure.

BOND TESTS.—Tests were made to determine the relative strength in bond of oil-mixed and plain concrete. Specimens were made of 1:2:4 concrete, mixed with 23½% of water, based on the weight of cement and dry sand, making a rather wet mix. Rods 12 ins. long were embedded in the center of cylinders 8 ins. in diameter and 8 ins. long, one end projecting about ½-in. through the bottom. The specimens were bedded in plaster of Paris on a cast-iron plate mounted on a spherical bearing lock. The test consisted in pushing the rods through the concrete, the point of failure being taken at the drop of the scale beam.

Two kinds of bars were used, plain and deformed. All specimens were tested at 28 days, and the results are plotted in Fig. 8. The points plotted represent the average of two sets, which in all cases ran very closely together. The results show that the effect of oil is to decrease the bond strength, the decrease depending on the quantity of oil added. It is evident that the bond between plain bars and concrete is affected so seriously by the admixture of oil that it would be extremely inadvisable to use such a combination. The bond of deformed bars is not affected so seriously. With an admixture of 10% of oil, which is as much as is necessary to use, the bond strength is 84% of that attained by the mixture containing no oil.

SERVICE TESTS.*—During April and May, 1910, two bridge surfaces of oil-concrete were laid at Ridgewood, N. J. In the Borough of Richmond, New York City, during May and June, 1910, about 400 ft. of street surface was laid with different aggregates. About 300 ft. of street in Washington, D. C., was surfaced in June, 1910. Numerous inspections of this work have been made, and, up to the present time, it is all in very good condition. About ½ mile of roadway, laid with 10% oil-concrete in the suburbs of Harrisburg, Pa., in the summer of 1910, is also reported to be in very good condition. A vault, 112 ft. long and 18 ft. wide, in the United States Treasury Department, was built in the autumn of 1910. The side walls of this vault contain 10% of oil. Its roof was constructed of ordinary reinforced concrete with about 3 ins. of 10% oil-concrete on top. For several months this roof was subjected to a head of water of several feet without showing any signs of leakage. Another vault, in the north end of the Treasury, on account of leakage, has never been available for storing anything of value. Its roof was treated with oil-concrete, and is now perfectly dry. Numerous floors in the sub-basement of the Treasury Department, and a floor in the Office of Public Roads, have been constructed with 10% oil-concrete, and have remained absolutely free from dampness. A tank, about 12 ft. long, 4 ft. wide, and 4½ ft. high, constructed in the Office of Public Roads during the winter of 1910, has been continually full of water, and has not shown the slightest signs of leakage.

*Described in Engineering News, July 20, 1911; p. 74.

SUMMARY OF CONCLUSIONS.—The following tentative conclusions as to the effect of the oils used in cement and concrete may be drawn from the foregoing investigations:

1. The tensile strength of 1:3 oil-mixed mortar differs very little from that of plain mortar, and shows a substantial gain in strength at 28 days and six months over that at seven days.

2. The times of initial and final set are delayed by the addition of oil, 10% of oil increasing the time of initial set by 90%, and the time of final set by 60%.

3. The crushing strength of mortar and concrete is decreased by the addition of oil to the mix, concrete with 10% of oil having roughly 75% of the strength of plain concrete at 28 days. At the age of one year the crushing strength of 1:3 mortar suffers but little with the addition of oil in quantities up to 10%.

4. The toughness or resistance to impact is affected but slightly by the addition of oil in quantities up to about 10%.

5. The stiffness of oil-mixed concrete appears to differ but little from that of plain concrete.

6. The results of tests for permanent deformation do not indicate that a law is followed by oil-mixed concrete.

7. Oil-mixed mortar and concrete containing 10% of oil have very little absorption, and, under low pressures, both are water-proof.

8. Oil-mixed mortar containing 10% of oil is absolutely water-tight under pressures as high as 40 lbs. per sq. in. Tests indicate that oil-mixed mortar is effective as a water-proofing agent when plastered or painted on either side of porous concrete.

9. Bond tests show the inadvisability of using plain bar reinforcement with oil-concrete mixtures. With deformed bars the bond is not weakened seriously by the addition of oil in quantities up to 10%.

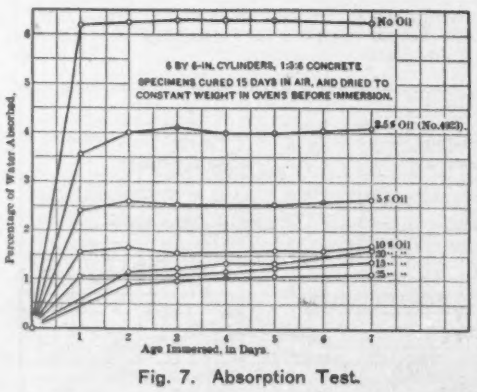
No Oil
6 BY 6-IN. CYLINDERS, 1:3:6 CONCRETE
SPECIMENS CURED 15 DAYS IN AIR, AND DRIED TO CONSTANT WEIGHT IN OVENS BEFORE IMMERSION.
2.5% Oil (No. 4923).
5% Oil
10% Oil
15% " "
20% " "
Percentage of Water Absorbed.
Age Immersed, in Days.

Fig. 7. Absorption Test.

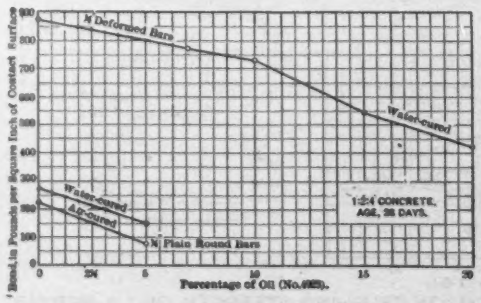

Fig. 8. Bond Test.

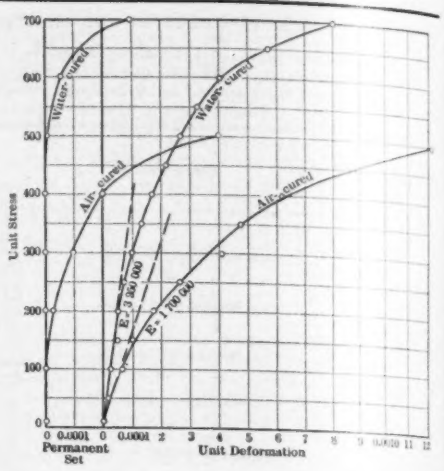

Fig. 6. Stress-Strain Curves, 1:3:5 Oil-Mixed Concrete (Mark No. 16, Age 28 Days, 10% Oil, No. 4923).

A patent has been granted to the writer for mixing oil with Portland cement concrete and hydraulic cements giving an alkaline reaction. All citizens of the United States are at liberty to use this process without the payment of royalties.

The writer takes this opportunity to express his thanks to A. S. Cushman, Assoc. Am. Soc. C. E., and Mr. A. T. Goldbeck for their most valuable assistance in conducting these experiments.

Cloth Pinions for Spur Gearing have been successfully used in connection with the operation of punches, shears and other machine tools where the gearing is subjected to sudden torque variations and shocks due to the taking up of back lash. It is claimed that these pinions are more silent and less liable to fracture than cast-iron or brass and that they are not subject, like rawhide pinions, to the attacks of rats and mice when kept in stock. Information has recently been given out on the construction of the cloth pinions developed by the General Electric Co., from experience in its own shops.

The blanks from which the pinions are cut consist of a filler of cotton or similar material confined, at a pressure of several tons to the square inch, between steel "shrouds" or side plates. The whole structure is held together by means of rivets, or in case of very small pinions, by threaded sleeves. After the teeth are cut, the cloth filler is impregnated with oil making the pinions self-lubricating. It is claimed that they are also entirely impervious to moisture, unaffected by changes in atmospheric conditions and absolutely vermin proof.

The teeth are cut to the 14½° involute system according to Brown & Sharpe's standard. Diametral pitch is the standard of measurement. The teeth are stronger, it is claimed, than those of any other type of non-metallic pinion, and are sufficiently elastic to allow the meshing teeth to bear evenly across the full width of face, thereby enabling the combination to absorb shocks which would fracture cast iron or brass. The pinions, therefore, have a long life. Of several thousands of pinions in operation under severe conditions for periods ranging from a few months to two years, none are reported to have shown any appreciable signs of wear.

The width of the cloth face is made equal to the width of the companion gear face plus the total end play of both shafts, so as to provide against any possibility of the shrouds running on the companion gear. Ordinarily, the pinions constitute the smaller members of the gear train, but practically any size and form of gear can be used, including gears of large diameter consisting of a spider with cloth filled rim.

Cloth pinions have been found to be particularly suitable for use on the shafts of back-geared motors employed for driving such tools as lathes, planers, drill presses, shears and punches; for loom and spinning-frame drive in cotton, silk, worsted, carpet and textile mills in general; for operating pulp and paper-mill machinery; for driving printing presses, and for the valve, ignition and timing gears of automobile and other types of internal combustion engine.

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The Dam Failures in Wisconsin.

The floods in western Wisconsin last week caused by the failure of some earth dams, coming so soon after the disaster at Austin, Pa., direct renewed attention to the need of greater care in the construction of dams of all classes in the interest of public safety.

While the Austin dam failure called general attention to a common weakness of masonry dams—water getting under the foundations—the Wisconsin dam failures were also due to a common cause of disaster—the most common cause probably of the failure of earth dams, viz., water overtopping the embankment by reason of the spillway being insufficient to carry off a heavy flood. It was this cause which brought about the destruction of the South Fork Dam and let loose the flood which devastated Johnstown.

The rainfall which brought high water against the dams in Wisconsin was not an extraordinary one, 3 ins. in 18 hours, according to the report printed elsewhere in this issue; but it came apparently on ground already well saturated; and it is evident that whoever was responsible for proportioning the spillways of these dams did not make sufficient provision for flood flow.

Important questions are raised by the Hatfield dam failure as to what provision should be made to safeguard a dam where the pond behind it may receive a sudden influx from the failure of a dam further upstream. Discussion of this and other questions in connection with the disaster we defer until the receipt of more detailed information.

Is Dam Construction in New York Under Sufficient Engineering Control?

In commenting on the Austin dam failure last week we said:

> There is not a single state in the Union where the design and construction of dams is under sufficient control of a high-class engineer acting under state authority and responsible for the public safety.

A correspondent in New York takes issue with our statement, above quoted, and sends us a widely published newspaper item reading as follows:

> An investigation of the condition of the dams and reservoirs in New York for the purpose of taking such precautions as will prevent the occurrence in this state of a calamity such as took place recently in Austin, Pa., is to be made under the supervision of the State Conservation Commission. Alexander Rice McKim, of New York, has been appointed by the Commission at an annual salary of $3,500, to conduct such an inquiry.
>
> Commissioner John D. Moore of the division of inland waters of the Conservation Commission, in response to many inquiries as to the condition of existing dams and reservoirs in the State of New York and the possibility of an occurrence such as that of Austin, has made the following statement:
>
> "Whether we have any weak or insecure dams in the State of New York is a thing which we propose to find out. Fortunately the conservation law clothes us with abundant power not only to find this out, but also to compel the owners of any dangerous dams to make them safe. A fine of $500 a day for non-compliance with such an order gives the law plenty of teeth and makes it effective. So far as I know New York is the only State in which the complete control of such structures is vested in the state authorities. There are more than 500 water power dams in the state, so this is an important duty.
>
> "We have a census which enumerates every water power plant in the state, and we now propose to have our inspector of dams examine them as speedily as possible. Three weeks ago we required the builders of a dam now in process of erection to greatly increase the strength of construction and have under consideration at the present time the plans of a half dozen other dams about to be built. Whatever may be the condition of the old ones, we are going to exert every effort to see that the new dams are absolutely safe."
>
> Matthew W. Hoover, of Lockport, a newspaper man, has been appointed "chief of publication" in the State Conservation Department. The salary is $2,500 a year.

The "Conservation law" referred to above was enacted by the legislature which adjourned last week, and we are not informed as to its provisions. The above item, however, bears internal evidence that it was the disaster at Austin which aroused the New York Commission to the importance of investigating the condition of the dams within the state, not only those now under construction but those already built.

Even so, does the appointment of a single engineer at a salary of $3,500 a year to investigate all the dams in the great State of New York constitute "sufficient control" to protect the public from danger?

We desire to go on record as saying emphatically that it does not. An engineer carrying such a responsibility should have at least twice or thrice that salary, and a competent staff in addition. The investigation of five hundred water-power dams (and we venture the guess that there are several times that number of dams and reservoirs in the state, great and small), is an enormous task, and a task of enormous difficulties. But the State Conservation Commission apparently thinks that $3,500 a year to an engineer will take care of the dams and a salary within a thousand dollars of that sum to a newspaper man to report to the public their achievements is about the proper distribution!

It is well within the resources of engineering to protect public safety in engineering structures; but the public safety will be sacrificed so long as the public tries to get along with cheap engineering and little of it.

The State of New York in particular has allowed the engineers in its employ to be the football of a political game. A man has never been sure of his position longer than a gubernatorial term, and not always so long. What inducement is there for a high-class engineer to hold a position in the State service, to give to it the best that is in him and to hold the public interest far above all considerations of personal benefit or political pressure?

We stand by our original statement without qualification, that there is not a single state of the Union where the design and construction of dams is under *sufficient* control of a high-class engineer to secure real safety to the public.

The nearest approach to a permanent engineering bureau to protect the public interests has been made by one or two of the Public Service Commissions. We venture to guess that dam construction in Wisconsin will hereafter be under control of that State's very efficient Public Service Commission. And this is one reason, we doubt not, why the Public Service Commission idea is unpopular with the politicians.

The Results of Public Utility Regulation in Wisconsin.

Those of our readers who still doubt the benefits of Government control of public utilities should read the remarkable address of Governor McGovern, of Wisconsin, presented before the recent Conference of Governors at Spring Lake, N. J., a considerable part of which we have reprinted elsewhere in this issue. The address is remarkable in several ways. It brings together in very concise and forceful way an exposition of legal and economic principles, a description of practical administration and a keen analysis of the resultant benefits. It has a quality not found in the address of a mere politician.

When the public-utility laws of Wisconsin were first enacted there were lugubrious predictions of disaster; but the actual results after four years' operation of the laws have shown great gains to the corporations as well as to the public. The railway operating revenues have increased 33%, in spite of the decreases in rates and improvements in service which have been made. The electric-power companies increased their operating revenues 20%, their net income 29% and their new construction 145%. Gas companies increased their operating revenues 3%, their net income 15% and their new construction 24%. Electric railways increased their operating revenues 13%, net income 8% and new construction 8%. Telephone companies showed an operating revenue greater by 11%, net income greater by 9% and an increase of 14% in new construction. The operating revenue of water utilities increased 7%, their net income 13% and new construction 24%.

These figures are eloquent evidence that the public utilities of Wisconsin have flourished under public control as they never did in the old days when the public was at the mercy of the promoter and manipulator.

There are also benefits which appeal particularly to those seeking better government, according to Governor McGovern. The utility companies are reported to be "absolutely out of politics," because there is nothing in politics for them; their status is ensured and their investments are protected without need of recourse to lobbying or the hundred schemes of political trickery which are seen elsewhere. They are said to be concentrating their attention on the details of their business, with resultant economy of service and cleaner politics.

The cost of all this public control of the machinery of service has been held up as a prohibitive tax on the business of the state. The quoted figures for Wisconsin show that an expenditure of $100,000 a year has led to an annual saving for the consumers of $2,000,000. That is, an initial expenditure of a dollar has yielded twenty, through economies and better use of facilities—to say nothing of the improved condition of all the utilities, which is less easily defined in dollars and cents. Considering the ambitious plans imposed on the Wisconsin commission and its large and highly trained organization, which includes experts of national reputation, this cost seems low compared with the vast amount of labor which has been performed.

It is worth noting that while Wisconsin owes a great debt to its State University for its leadership in making the state foremost in the Union in its system of public utility regulation, the University has also benefited.

Its teachers of engineering and economics have been no mere class-room theorists, but men who were obliged to square their theories with the facts of practical business; the opportunity for leadership thus given and the results achieved have given the University fame throughout the world; and have, we are sure, been a source of inspiration to its students.

A Needed Reform in Locomotive Throttle Valve Design.

Elsewhere in this issue is illustrated a notable innovation in the design of locomotive throttle valves. Instead of placing the throttle valve inside the steam dome, according to universal practice, Mr. W. L. Buck, Supt. Motive Power of the Santa Fe system, has built a locomotive with the throttle valve outside the boiler shell, close to the cylinders. The bravery of such a radical innovation in locomotive design is deserving of special mention, but we wish Mr. Buck might have been brave enough to have gone one step farther and discarded the double-poppet throttle, universally used in America, and adopted in its stead the European type of slide-valve throttle. That the American type of throttle valve works as well as it does is a tribute to the excellence of American workmanship and perhaps of American patience. The difficulty in keeping steam-tight the balanced throttle, if the most microscopic difference of expansion occurs between the valve and its casing, is pretty well known to railway-shop men, and has been long endured as a necessary part of the troubles of life. With the European type of slide valve throttle this difficulty disappears.

The chief advantage, however, of the European type of throttle, and the reason why it ought to be adopted in this country, is the possibility of fine graduation of the throttle when the locomotive is starting and the consequent reduction in the slip of driving wheels. Every railway man who has traveled much abroad must have been impressed with the smoothness and quietness with which the European locomotive gets its train under way. We believe the main reason for this is the slide valve throttle used. This has a small relief valve, riding on top of the main valve, which gives steam enough to the cylinders to start the train and can be finely graduated. With this relief valve wide open, also, the pressure on the back of the main slide valve of the throttle is so reduced that it, too, can be moved with little friction.

Trust Methods In Selling Cement.

About a year ago control of a large part of the cement output of Canada came into the hands of the Canada Cement Co. Since that time all of the cement produced by the company, regardless of the mill in which it may be made, is sold in bags uniformly labeled "Canada Cement Co.," with no other distinguishing mark whereby the consumer may know which of the hitherto well known brands he is buying. In consequence, there is a marked disposition among cement users to ascribe any troubles with concrete to uncertainty regarding the source of the cement.

Commenting on the failure of the Canadian Fairbanks-Morse Building, in Winnipeg, noted in our last issue, a prominent Canadian engineer writes us:

> There is no question but that architects, engineers and contractors would much prefer that the Canada Cement Co. would revert to the practice of so marking the cement output that its source and brand could be known at a glance and more confidence could be felt in its free use.

Except in the case of governmental or large corporation work, it has never been the custom in Canada, nor is it practicable there, for the consumers to make their own tests of cement. Consequently they have had to depend on the reputation of the various manufacturers, who, in turn, were forced by competition to keep their product up to certain standards. Independent manufacturers have taken pride in the reputation of their own brand of cement and have realized the necessity of care in its production to maintain their reputation. These incentives to high quality are lacking where the product of all the mills goes into one hopper.

It is true that the Canadian Cement Co. guarantees its cement to comply with the standard specifications of the Canadian Society of Civil Engineers; but this guarantee at best means no more than an assurance that every effort is made to produce satisfactory material. There is no redress for the Canadian cement consumer if the material is unsatisfactory, except to purchase more material from the same source.

While the product of each mill is doubtless regularly tested, it is a great additional stimulus to a mill organization to know that its productions can be identified by the purchaser and that the quality of its product will make or mar its reputation. Besides there are certain differences in the color and the quality of cement from different localities and different materials which may be of some importance to the user.

There is no apparent reason why each mill operated by the Trust might not have its own brand, so that the consumer might have an opportunity at least for selection and so that the origin of any cement which proves defective might be known.

If the final result is a more general adoption of testing by the cement purchaser, it may be a benefit to the industry. But there will first have to be developed a more simple method of cement testing than is now generally used. In view of the wide divergence in results under the present complicated methods of testing, however, there is a large field for improvement in this matter.

State Supervision of Engineering Work.

A year ago, when agitation was active for the establishment of state bureaus to license engineers and compel them to pass examinations in order to practice their profession, we urged in the strongest terms that such measures would not promote public safety, and that the way to protect the public was for the state to inspect the work of engineers rather than attempt to test the engineers themselves.

The terrible disaster at Austin, Pa., has been an object lesson as to the duty of the State to protect its citizens against such dangerous structures. Gov. Tener of Pennsylvania, after examining the ruins at Austin, publicly declared that he would urge upon the Legislature the enactment of a law requiring all dams built in the state to be supervised by a competent state authority.

We emphasized this in our last week's issue as one of the chief lessons which the public ought to learn from the Austin disaster. It is a narrow view, however, that limits any such movement for reform to the particular calamity which happens to be uppermost in the public mind. It is no more necessary for public safety that the state should supervise the construction of dams than it is the construction of bridges; no more necessary to supervise bridges than public buildings. There is in fact a long list of engineering works which if wrongly carried out may cause injury to life and property.

Everywhere the movement at the present day is to establish governmental inspection and control over works which affect public safety and public welfare. It may be granted that most of the structures built by private concerns are built well and honestly; but there is always danger that an irresponsible concern will sacrifice safety for the sake of gain and the public has a right to protection against such dangers. But if it be granted that the state owes this duty of supervision of various engineering works whose faulty construction may prove dangerous, the question arises, how may this supervision be effected?

Experience has proved that inadequate or slipshod state supervision may be as bad as none at all. By way of illustration: an incident was reported to us within the last week where a dam was to be built in a state which requires the approval of certain authorities of the county in which a dam is located before its construction can be proceeded with. Plans were prepared for a structure which approached the safety limit pretty closely and advice concerning these plans was asked of a well-known engineer of high standing, whom we will call Mr. H. After examining the plans, Mr. H. advised that the dam section proposed was lighter than should be used. Shortly afterward these same plans were submitted to the county authorities with the bland statement that they would doubtless find them all right as they had been submitted to the eminent Mr. H.! The county functionary said at once, "Oh! If Mr. H. has examined them, it is needless for me to make any examination," and the permit was signed without another word.

It is needless to say that if state supervision is to be really effective to protect the public from danger, it must be made systematic and efficient; and it cannot be made efficient until the public learns two things: first, that to secure a state engineer who can be relied upon to protect the public interests, a man must be selected without regard to politics, he must have reasonable tenure of office and he must be paid a high enough salary to induce a really competent and high-class man to take the position.

We say, a state engineer; but there should be in every state not merely a state engineer but a state engineering bureau. Not only its head but its associates should be paid a salary sufficiently high to induce high-grade men to take the positions, and not be tempted away by advantageous offers from private concerns.

To show that we are speaking with full knowledge, we may say that within a few weeks the state engineer of one of the Western states, in a personal letter to one of the editors of this journal, declared his intention of retiring from office at the end of his term and taking up private practice, because he could no longer afford to hold the office of state engineer with its small salary.

The office of state engineer should, of course, be appointive and not elective. It cannot be expected that either a party nominating convention or a public primary can select a man with the professional qualifications necessary to discharge properly the duties of such an office.

The objection may be raised that the establishment of such state supervision will hamper engineering work; will tend to tie it up with "red tape" and endless restrictions. This objection will not hold, however, if the office is filled by the right sort of man.

Elsewhere in this issue we print a paper by the Governor of Wisconsin showing how the establishment of state supervision over public utilities in Wisconsin has greatly improved the methods under which the local water-works, gas-works and street railways in Wisconsin are carried on. The same result has been recorded where state supervision over plans for local water-supply, sewage disposal, etc., has been established. Local communities have been greatly aided in solving their engineering problems by the state engineer's office. State inspection of bridge plans and bridge inspection has been of great benefit to the taxpayers in improving the character of bridge construction, putting a check on petty graft in bridge contracts, and fostering better types of structure.

There is not the slightest doubt that the establishment of a high-class state engineering department in every state of the Union would pay the taxpayers of the state many times over its annual cost, in addition to the benefit it would bring in the protection of the public from danger.

What's What in Public-Health Work.

It is a hopeful sign of the times that a number of the ablest sanitarians in the United States are trying to answer the question, What's What in Public-Health Work? Elsewhere in this issue we publish two notable discussions of this subject, written independently, but agreeing in all essential particulars.

We refer to Dr. Hill's "The Relative Values of Different Public-Health Procedures," an original contribution to our columns, and to Prof. Jordan's "Profitable and Fruitless Lines of Endeavor in Public-Health Work," which we have condensed somewhat from a recent public address.

The gist of the two articles is that much of the work which is done in the name of public health has little or no vital relation to health, however important it may be to comfort and convenience. If this were a more pedantic matter of classifica-

tion of public activities it might be passed over by all save the academicians, but it is of vital significance, since in many cities and states genuine public-health work is inadequately conducted, largely through lack of financial support. In some instances the meagerness of the appropriations for real health-protective work is in considerable part due to the heavy sums put in the hands of the health department to pay for garbage collection and disposal, street cleaning and in rare instances even the maintenance and operation of sewerage systems.

All these operations, as well as plumbing inspection and some other work commonly assumed by or imposed upon boards of health, are elements of "municipal housekeeping," to use a all-inclusive term suggested by one of our authors. We prefer the current British term, municipal cleansing, broadened in its application to cover all work for the removal of wastes and the suppression or prevention of nuisances due to both putrefactive and non-putrefactive dirt—using dirt in the broad sense of "matter out of place," and making it include all sorts of dust, smoke from chimney stacks, etc.

The underlying principle common to both the articles we are considering is that, at least for the present, the chief work of boards of health should be directed against the spread of communicable diseases, and that such work starts, continues and in an ideal state would end with stopping infection before it begins; or in preventing any of the infected discharges of the sick or of carriers from gaining access to the systems of non-infected individuals. In saying this neither we nor the authors of the papers overlook numerous other lines of legitimate health-protective work, several of which are being advantageously pursued by a few boards of health, while others will properly come to the front for general attention when greater progress has been made in suppressing communicable diseases.

Our own ideas, and perhaps those of our two authors, may be reinforced by a quotation from one of the most notable of recent contributions to health-protective literature, Dr. Charles V. Chapin's "Sources and Modes of Infection." Summing up his discussion of the continued existence and possible origin of the germs of communicable diseases outside the human body Dr. Chapin says:

REVIEW OF EVIDENCE.—In reviewing this subject we are forced to the conclusion that while it is possible that the anthrax and tetanus bacilli and the pus-forming bacteria may develop in the soil, there is no evidence that they commonly do so. It is also possible that the typhoid bacilli, and to a still less extent the bacteria of cholera, dysentery and plague, maintain a limited saprophytic existence, but this is probably very unusual. There is ample epidemiological evidence that in temperate climates such a source for these diseases must be an almost infinitesimal factor in development. Probably the diphtheria bacillus never has a saprophytic growth of any significance, unless possibly very rarely in milk. As for tuberculosis, pneumonia, influenza, cerebro-spinal meningitis, scarlet fever, typhus fever, small-pox, whooping cough, gonorrhea and syphilis, malaria, and yellow fever and sleeping sickness, there is not the slightest reason for supposing that they ever develop outside of the bodies of animals.

CHANGES IN PRESENT THEORIES AND PRACTICE.—If the facts are correct—and I scarcely believe any will seriously contend that we have evidence that an appreciable amount of our common infectious diseases arise in the external world—prevailing notions as to the sanitary functions of the state should be decidedly modified. The laity and the lay press still believe that the most of the infectious diseases have their origin outside of the body, in filth, or if admitting contagion, attach equal importance to external sources of infection. And even very many health officials and some teachers and some writers on sanitation hold the same view. Municipal sanitation and municipal cleansing are still synonymous terms to many health officers. It is true enough that two or three diseases, as typhoid fever and cholera, the germs of which are found in human excrement, have markedly diminished as a result of improved methods of excrement disposal, or because of the introduction of water supplies uncontaminated with human excrement. It is also doubtless true that whatever promotes municipal cleanliness tends to promote personal cleanliness, and real personal cleanliness, as we shall see, is doubtless an important factor in the prevention of contagion. But except for one or two diseases, and except for very indirect effects, the cleansing of the streets, alleys, and back yards of dwellings and stables, the regulation of offensive trades, and the prevention of nuisances generally, have, so far as we can see, no relation to the general health, nor any value in the prevention of specific diseases. While municipal improvements such as the above are desirable, there is little more real reason why health officials should work for them, than there is that they should work for free transfers, cheaper commutation tickets, lower prices for coal, less shoddy in clothing or more rubber in rubbers,—all good things in their way and tending towards comfort and health.

The foregoing words are not those of a theorist nor yet of a novice in health-protective work. They are based on the practical experience of their author as health officer of Providence, R. I., for more than a quarter of a century (since 1884), combined with the eager accumulation of world-wide evidence on the subject and with profound reflection on this evidence and on the results of his own practical experience.

We have attempted neither to epitomize the two papers which we print elsewhere, nor to express our own views on the same subject, farther than to direct attention to and place in a clear light the papers themselves.

The ideas expressed in the two papers and in the quotation from Dr. Chapin's book have an important bearing upon the every-day work of many of the readers of Engineering News, because they tend to place sewerage and sewage disposal, garbage collection and disposal, street cleaning, plumbing, heating and (indirectly) some water-supply problems, in their proper relations to health-protective work on the one hand, and to municipal cleansing, general comfort and convenience on the other.

Besides this, the ideas of the three authors give assistance in solving the vexed problem of wisely distributing the limited funds of our cities, state and nation among the innumerable objects for which appropriations are demanded.

Until sanitarians reach approximate agreement on what's what in public-health work and spread the knowledge abroad we must expect to see a mis-distribution of public funds to various objects of expenditure, which is not far different from misuse. Worse than this, of course, will be the continuance of a vast unnecessary sacrifice of health, happiness and life due to the failure to do all that is possible to control infection at its fountain head, which is the individual suffering from or harboring the germs of communicable diseases.

What is the Permissible Intensity of Secondary Stress?

The extensive development of bridge engineering during the last decade has quite logically led bridge engineers to recognize secondary stresses as an essential factor in design. As bridge proportions have grown more condensed, more stubby, cross-sections broader, and the transverse tying more rigid, there has been a very great increase in the relative importance of local bending actions as compared with the primary stresses. This fact is well appreciated by the practical engineer, and if the actual calculation of secondary stresses is made only seldom, yet their existence is allowed for in various ways.

The future is bound to see more frequent calculation of secondary stresses. The clear exposition of a short and convenient method of computation, given by Mr. F. C. Kunz in our last issue, will prove of great utility to the designer. And incidentally the attached discussion of various practical questions concerning secondary actions should prove almost as valuable. But the final use which the designer is to make of secondary stress, subsequent to the mathematical calculation, depends on a question that is up to now unsettled, and indeed has received little (if any) discussion.

The question is, what allowable unit-values shall be applied to the secondary stress? Writers on secondary stress do not give explicit consideration to this matter; they either end their discussion when they have shown how to carry out the computations, or they state directly that the secondary stress is to be added to the primary, in order to find the total stress. There are reasons for believing this latter to be not necessarily the correct procedure, and the question as a whole deserves full and penetrating discussion.

To illustrate the point at issue, take the case of a compression member in a large bridge. Such a member usually has reverse bending at its opposite ends; the secondary stress (in the main cross-section) is maximum at the ends and is zero at some intermediate point. It is known that the primary stress is maximum at midlength, and less at the ends. To add the maximum secondary stress to the midlength primary stress would not appear to be proper, therefore; this course is in effect commonly recommended, but it seems to involve an error, which in some cases may be beyond the negligible order. But a much more weighty consideration is this: Does the secondary stress constitute as great a menace to the integrity of the member as the primary stress? We think not; and if we are right, then a materially higher unit-stress might be allowed for the secondary than for the primary.

In case of the compression member with secondary moments of the same sense at opposite ends (reverse bending), the column action of the member is not perceptibly affected by these moments. In so far as the design of the member is based on its efficiency as a column, no great account need be taken of the secondary stress, therefore. On the other hand, looking to the stress conditions at the ends, we will not be able to discern any serious danger if the extreme-fiber value of primary plus secondary attains a high figure. Suppose even that the extreme-fiber stress at the ends reached the yield-point: it would only result in such readjustment of the member as would decrease the distortion-bending, i. e., the secondary stress. And this action, it may be said, is pretty generally characteristic of secondary stresses; that is, they tend to relieve themselves whenever they produce a local concentration high enough to bring about any yielding.

The less common case of the compression member with end moments of opposite sense (one sided bending) presents a modified condition. It is to be noted that the very bending which the secondary stress involves deflects the member into a position where it is adjusted to the truss distortion. In other words, the secondary stresses cannot be as high as their computed amounts, possibly not even half as great. (This occurs also in the case first considered, though probably in much smaller degree.) Every action, in fact, that is likely to occur in the member during its existence will be such as to reduce the secondary stress and tend to bring about an adjustment of the member to the truss distortion.

The same conditions affect tension members in almost the same way. And here we must recognize further the probability that all continuously-existing secondary stresses, as for example those due to the dead-load, will tend to disappear gradually in all pin-connected members. The minute vibrations produced by traffic, and all other disturbances and changes in the truss, should operate to permit those slight rotations on the pins which correspond to relief of the secondary.

Briefly, these considerations suggest that secondary stresses should not be rated as high as primary stresses; greater unit-stresses might be allowed for them. To examine fully whether such a conclusion is justified calls for a detailed study of the subject, and we hold that such study is needed before correct practical application of secondary-stress computations can be made.

By no means, however, would we intimate that secondary stresses should be wholly neglected, merely on the theory that they are in part self-relieving and do not concentrate at critical sections. For it is to be recalled that the so-called secondary stress is only one of a number of sec-

ondary stresses, and represents at best a crude estimate of *a small part* of the stress-additions to the primary. The bridge engineer is fully aware that the transverse distortion of the bridge—the floorbeam influence and the effect of the sway connections—involves very important stresses not included either in the primary or in the so-called secondary. Less commonly is it recognized that temperature expansion is also a momentous factor in producing various kinds of secondary stresses, both by deforming the bridge as a whole and by setting up internal strains in the individual member. All these various sources of stress should (theoretically) be taken into account in the analysis of a bridge, but are not. Since some are left out of the figuring, then, it would be wrong to throw aside entirely that single variety of secondary stress which we can compute; good designing does not countenance any lower margins of safety than our current unit-stresses afford when applied in utmost strictness. However, the common secondary stress should not on this account be counted at full primary unit-stress value, but only at such reduced value as conservative estimation of its relative importance may select. Any allowance beyond this is likely to be no real gain, as the various unconsidered secondaries will most likely concentrate at sections where the extra allowance does not give added metal.

With further reference to the several unconsidered sources of stress in bridges, we may suggest that the bare term "secondary stress" is somewhat misleading and undesirable, if used to denote only the stress chargeable to truss-plane distortion. A range of qualifying terms is available to denote the kind of stress more truly, and such terms should be chosen and used. We may apply the term "truss secondary" to the ordinary secondary stress; "sway secondary" to that caused by distortion of the rigid frame of post, floorbeams and upper strut; "temperature secondary" to the stress arising from one-sided heating, etc. Such distinguishing terms are almost inevitable if, as we believe, the temperature secondary will in future receive special study and be frequently regarded in design.

LETTERS TO THE EDITOR.

Concerning Hydrostatic Pressure Under Dams and Hooped Columns of Reinforced Concrete.

Sir: The current issue of Engineering News [Oct. 5] records two awful demonstrations of principles that I have been emphasizing for a number of years. This letter is not written to say, "I told you so," but rather that I am going to keep on emphasizing these principles as long as I can or until they are generally accepted. It takes years and years to pry loose from a body of professional men theories and hypotheses that they have held as standards and sometimes it takes a large number of awful wrecks. As Pasteur was hated, and persecuted, and ridiculed, when he advanced his germ theory of diseases and told the medical doctors to wash their hands when they went from one patient to another to avoid carrying disease, so anyone who advances a theory contrary to common practice in engineering may expect the same treatment. See what the medical profession (?) has done by their discovery of the germ theory of diseases. (Pasteur was not a medical doctor.)

The principles that are demonstrated by incidents recorded in Engineering News Oct. 5, 1911, are these:

(1) Slender longitudinal rods do not reinforce a concrete column. This universally accepted standard of designing columns is utterly wrong and absolutely dangerous.

(2) Properly designed dams must be capable of resisting upward pressure of water beneath them. The universally accepted standard of designing dams is utterly wrong and absolutely dangerous.

The failure of the building in Winnipeg, Man., is a demonstration (one of many) of (1). Natural cussedness of cement will probably get the blame here, as it is not shown that the usual handful of shavings could be located. Authorities can be found by the pound, or, in scientific degrees, by the yard, that will give their full sanction to these columns which failed, just as Pasteur could have been buried in expert medical opinion of his day that would completely refute (?) his germ theory.

The failure of the Austin dam is a demonstration (one of many) of (2). An agitation against building dams regardless of this pressure was begun in 1895. It was revived in 1904. In 1908 an expert report stated that the Austin, Texas, dam, which failed in 1900, went out because of under pressure. In 1910 one lone solitary book on dams actually mentioned this pressure, and that on the first page. The present year has seen a published sketch which considers it, made by an author who in 1895 showed to his own satisfaction that the under pressure deserves no consideration. Eleven years, four, two, one—the year of general acceptance of this principle, which is as easily demonstrated as the area of a sphere, seems to be drawing near.

If it takes 18 years to prove to engineers the danger of concrete shafts with slender rods in them masquerading as reinforced-concrete columns, we can expect universal acceptance in about 1924, with wrecks every few months in the meantime."

Edward Godfrey, M. Am. Soc. C. E.

Monongahela Bank Bldg., Pittsburgh, Pa., Oct. 6, 1911.

[Unfortunately for our correspondent's argument as to the weakness of hooped columns with vertical reinforcing rods, the floors in the Winnipeg building stood up under the shock of the falling roof. This is additional evidence that the failure was due to the concrete not having set sufficiently when the forms were removed, as stated by the engineers who furnished us the report on the accident. How a failure of a structure on account of green concrete proves or disproves anything as to theories of design is not clear to us.

As for water pressure underneath dams, there are two things to be done, either so design the dam section that it will have a good factor of safety with hydrostatic pressure beneath it, or so design the dam and its foundation, by drains and otherwise, that water pressure cannot accumulate beneath or in the structure.—Ed.]

The Public Land Surveys Again.

Sir: The abominable way in which some of the public land survey contracts have been carried out is only too well known by those who have had anything to do with engineering work in the West; but the work being done at present by some of the Government surveyors is more haphazard and careless than the old contract surveys.

A person who has had practice, could set section corners by pacing the distance about as accurately as is being done by some of the Government surveyors. We have been told by men who have charge of parties that the work is done in a worse manner now than then, because there is now no inspection, and the field men are continually hurried by "the ones higher up." In order to hold their jobs they do the work in the quickest way possible.

Eight days is the average time in which it takes a certain party to complete a township; and this in rough country. In sectioning a township, with back tracking, the chainmen would have to walk 133 miles; add to this the distance to and from camp, and consider whether the work can be done accurately or not in that period.

That it is going to cost the Government a trifle more to have the work done accurately is a certainty, and that in many places the land is not worth the money expended is also true; but why do it at all if it cannot be done right?

There is only one redeeming feature to the present system; that is the brass-capped iron pipes to mark the corners, which have all the promise of being permanent; but we know of several of these corners that are wrongly marked. The errors were called to the attention of the one in charge, but the mistakes were never corrected; this in spite of the oath he took to do the work to the best of his knowledge and ability.

Who is responsible for the utter carelessness displayed in the work, we are unable to state, but if reports are true, if a few office "pinheads" were placed out in the desert and given an ax or made to carry a few iron pipes across canyons and over rim rocks, and a few "reputation hunters" eliminated, the sectioning of public lands in the United States would be done a little more carefully and accurately. A rigid inspection seems to be necessary.

Some of the men engaged on these surveys are not under the Civil Service and hold their positions owing to the fact of having held contracts under the former system, and some of them do not know the difference between a compass and a level.

G. B. Louden, Civil Engineer,
E. A. Shafer, Civil Engineer.

Narrows, Oregon, Aug. 28, 1911.

Queries in the Design of Dams Raised by the Failure of the Dam at Austin, Pa.

Sir: In common with the rest of the newspaper reading public I have read with interest the accounts of the failure of the dam at Austin, Pa. According to the accounts as printed in the New York "Tribune" this morning (a part of their information having been taken from Engineering News) this dam was a massive concrete dam with a vertical up-stream face; in fact, a somewhat similar design of cross-section to the dam at Austin, Tex., which failed some eleven years ago.

Being somewhat familiar with the history of dam construction and the history of dam failures the thought which makes the strongest impression on me is "Why do engineers continue to design dams that can fail in the manner described for the failure of this dam at Austin, Pa., and as previously exemplified by the failure of the dam at Austin, Tex.?"

Probably the only general type of dam which has usually been exempt, or practically exempt, from failure is the type of a dam in which the water pressure is made to make the dam stable by its weight; that is, a dam with a comparatively flat inclined upstream face. The water pressure, being always at right angles to the surface against which it comes in contact and having a net resultant only a third of the way up from the bottom of such surface, will on such a flat inclined exposure be itself the means of holding such a dam where placed, and the problems of the engineer in connection with the design of such a dam are practically reduced to the design of a structure sufficiently strong to give support to this weight of water so imposed. If the inclination of the exposed surface is about 40° the resultant pressure on the base foundation will easily be made to come in the exact middle of the base or even upstream from the middle, and when the weight of the dam itself is taken into consideration this resultant pressure will be perhaps not more than 20° from the vertical. The factor of safety in such a design can be taken as described, and not (as is the case in the usual solid gravity dam) at only a very slight margin above the strength for failure. On a dam with the inclined face there need be no base to give surface for upheaving water pressure underneath, as all that is required of the under structure is to support the deck against which, and on which, the water rests, and any leakage or any seepage through this deck will do no harm except the wastage of a little water. Dams of this type have been built for centuries. Some of the oldest and most prominent dams in this country have been built with an inclined wooden deck supported on rock-filled cribs of timber and, whatever the foundation underneath, these dams are safe. There is absolutely no chance for overturning such a dam and the chance of sliding the same is an absolute minimum.

The newer development in this type of dam (as is the case of the newer development in almost all kinds of construction) is the adaptation of the same to reinforced concrete, but as a matter of fact this type of dam is probably the oldest and most reliable and safest of any type in use, besides which considerations it will usually be found to be by far the most economical.

When will engineers stop creating such a huge unnecessary force as the water pressure against a vertical or practically vertical upstream face of a dam and then spend their time and ability and the money of the prospective owner in overcoming this absolutely unnecessary overturning horizontal force, and after it is all done obtain a huge costly pile of masonry which at best has practically no factor of safety against overturning or sliding? Why not use this great force of water pressure, in designing a dam, to actually aid in (or rather to actually be the means of) maintaining the dam to be built in its position and turn the completed structure over to the community with no force whatever in flood time or otherwise that would destroy the valuable property constructed, and also, as in the

case of this disaster at Austin, Pa., cause such an unnecessary toll of lost lives of innocent, unsuspecting people?"

Wm. M. Torrance.

39 Cortlandt St., New York City, Oct. 2, 1911.

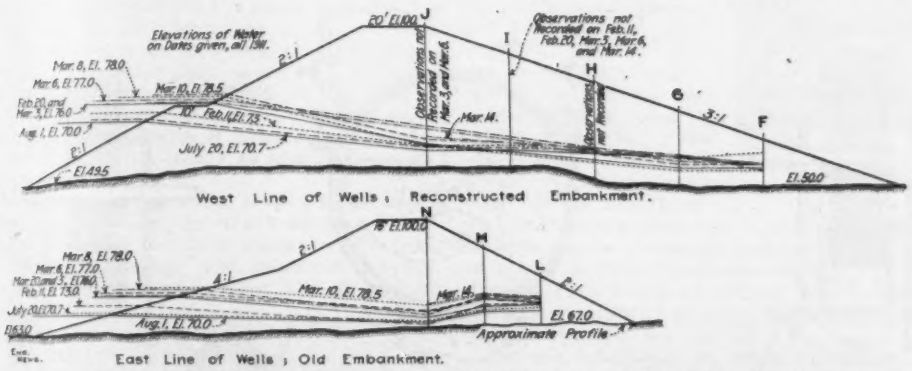
[Probably the reason why the sloping side of a masonry dam is placed downstream in standard engineering practice is that the engineer must provide safe passage for the water going over the crest of the dam in time of flood. Unless one can build a hollow dam, therefore, the slope must be placed on the downstream side if the dam is to permit overflow for the whole length of its crest. Of course, with reinforced concrete a hollow masonry dam can be economically built; but it is only within recent years that this material has been available for dam construction; and even now when building a monumental structure intended to endure indefinitely, many engineers prefer to use solid concrete and not rely on reinforcement for strength.—Ed.]

Lines of Saturation in the Jumbo Dam, Colorado.

Sir: The accompanying illustration shows the lines of saturation in the old and in the new embankment of the Jumbo reservoir dam belonging to the Julesburg Irrigation District, in Sedgwick County, Colo.

This dam failed on March 11, 1910. The break was afterwards repaired in accordance with plans prepared by Mr. Geo. T. Prince, M. Am. Soc. C. E., of Denver, Colo., and under his supervision.

The reconstructed embankment has a somewhat different section from that of the old dam and the material was more carefully placed. On the reconstruction the earth was placed in 8-in. layers, sprinkled and consolidated by teaming over it. On the old embankment the earth was placed in layers of approximately 3 ft., with no special effort to consolidate it.


Elevations of Water on Dams given, all 1911.
Mar. 8, El. 78.0
Mar. 6, El. 77.0
Mar. 10, El. 78.5
Feb. 20, and Mar. 3, El. 75.0
Feb. 1, El. 73.
Aug. 1, El. 70.0
July 20, El. 70.7
El. 49.5
El. 50.0
Observations not Recorded on Feb. 11, Feb. 20, Mar. 3, Mar. 6, and Mar. 14.
Observations not Recorded on Mar. 3 and Mar. 6.
Mar. 14.
20' El. 100.0
West Line of Wells; Reconstructed Embankment.
18' El. 100.0
Mar. 8, El. 78.0
Mar. 6, El. 77.0
Mar. 10, El. 78.5
July 20, El. 70.7
Aug. 1, El. 70.0
El. 67.0
Approximate Profile
East Line of Wells; Old Embankment.

LINES OF SATURATION IN OLD AND NEW PORTIONS OF EARTH DAM, JUMBO RESERVOIR, COLORADO, AS OBSERVED ON DIFFERENT DATES IN 1911.

After the reconstruction there was still some leakage below the toe of the new embankment, and with a view to determining whether any considerable amount of water came through the dam two lines of pipe wells were located at right angles to the axis of the embankment.

These two lines are approximately 100 ft. apart, one being in the new embankment and one in the old. The wells in the new embankment were spaced 27 ft. apart horizontally; those in the old embankment were spaced 18 ft. apart horizontally.

The results of observations on various dates are shown by the illustration.

Charles W. Comstock, State Engineer.

Denver, Colo., Sept. 12, 1911.

A Word in Defence of the Non-Graduate Engineer.

Sir: While I am entirely in favor of the adequate compensation of engineers, I wish to say a word for the large number of men on railroad surveying parties who are not graduates of technical schools and who seem to be so universally condemned by "Subscriber" in your issue of Oct. 5 On general principles, I, of course, believe a technical education is a very necessary foundation for an engineering career, but I am afraid that my own experience with men on locating parties on railroad surveys, is that of most other men who have been responsible for getting results, and that is that I am rather inclined to be afraid of the engineering graduate for that kind of work. I have known some who were entirely all right. I have had many more whose ideas of what they should do were far above the routine work of a survey.

I have had many young men as chainmen, rodmen and instrumentmen who were not graduates, yet were thoroughly competent to fill the positions they held, and on the whole have found their work far more accurate than that of the graduate. I have in mind one leveller in particular whose education in general was almost rudimentary; he was with me a long time, and ran several hundred miles of levels without a single error of moment, and I had many opportunities of checking his work.

It is probable that there are a larger proportion of men who are not graduates of technical schools on locating parties than elsewhere, and, of course, one finds on this work as on any other all sorts of standards and all sorts of men. On the whole, however, I believe the usual run of men to be found on locating parties, in spite of their lack of technical training, are as conscientious, intelligent and competent **for the work they have to do,** as any class of men in the profession. Yours very truly.

F. Lavis.

50 Church St., New York, Oct. 7, 1911.

Subway Clearance Dimensions.

Sir: In your issue of Sept. 21, 1911, I notice the "Clearance Dimensions of the Rapid Transit Subways," and the statement that the Brooklyn Fourth Avenue Subway is the largest. This statement is misleading and erroneous.

The Cambridge Subway is 14 ft. 9 ins. from top of rail, while the Brooklyn Fourth Avenue Subway is 15 ft. from base of rail, or only 14 ft. 6 ins. from top of rail. In fact, all clearances in the diagrams are shown from top of rail, except the New York subways, which are shown from base of rail and therefore appear excessive.

In this connection it should be stated that the Public Service Commission increased the clearance of the Brooklyn Fourth Avenue Subway from 13 ft. 6 ins. to 14 ft. 6 ins., in order to induce the Brooklyn Rapid Transit Co. to compete for the operation, and incidentally to improve ventilation and lessen the train resistance due to air friction. The increase of cost was estimated to be 2½%.

The subsequent offers from the Brooklyn Rapid Transit Co. and the Interborough company illustrate the value of such competition.

Henry B. Seaman.

165 Broadway, New York City, Oct. 4, 1911.

More About Sewage Disposal in Minnesota.

Sir: It is with more than passing interest that I read Mr. Abbot's letter in your issue of Sept. 28, 1911. I quite agree with what is said in your editorial note, but must take issue with Mr. Abbot.

It so happened that the writer was called upon by the city of Canby about three years ago to prepare plans for a sewer system.

I found that the sewer outlet would be a small stream which was then flowing about 50 gals. per min. I told the council that it would be necessary to treat the sewage and prepared my plans accordingly. The plans to some extent have been carried out. I was not aware of the previous troubles in connection with sewerage until I read Mr. Abbot's letter.

For my own part I consider leaching cesspools far less a menace to public health than such an accumulation of filth as must result in discharging untreated sewage into such a little brook.

I would also like to call your attention to the fact that the present engineer for the State Board of Health, although a professor in the University, was not connected with said board until several years after 1904 when the famous edict was issued and that Mr. Abbot must refer to some other person. John Wilson.

Duluth, Minn., Oct. 2, 1911.

[The relative dangers from leaching cesspools and from the discharge of sewage into a small stream would depend upon a variety of local conditions. Mr. Abbot's reference was to a university professor who served gratuitously in an advisory capacity, and not to the sanitary engineer added to the regular staff of the board years afterwards.—Ed.]

A Close Estimate of the Available Energy in Sunshine.

Sir: Referring to your article on a Sun Power Plant in issue of Sept. 21: As President of the Oklahoma Society of Engineers, I said to them on Dec. 27, 1909:

The greatest engineering possibility that I have in mind is the harnessing of the sun's heat, the greatest known power. This heat is wasted all around us every day in the year. A very low estimate of the equivalent of the effective heat of the sun at and near the surface of the earth is one ton of coal per day per acre. Within the corporate limits of Oklahoma City (embracing 7,000 acres) the sun's heat that is now wasted would furnish over 400,000 HP. for 10 hours a day which, capitalized at present values would be worth about $80,000,000. It is too great an asset to remain undeveloped. Its control may not be realized in 1910, but it must come.

Now 400,000 HP. from 7,000 acres is approximately 762 sq. ft. per HP., as compared with 686 reported from the Philadelphia experiment. Close enough for all practical purposes at the present stage of development.

H. V. Hinckley.

Oklahoma City, Sept. 25, 1911.

An Expert Investigation of the Austin Dam Failure.

Sir: At the request of the Bayless Pulp & Paper Co. I made an examination of the ruins of the dam at Austin, Pa. The failure of this dam teaches some important lessons about the construction of masonry dams which I intend to discuss fully on some future occasion. There is one point, however, to which it may be of interest to direct attention at the present time.

In the report about the stability of the dam and the required reinforcement, which I made in February, 1910, to T. C. Hatton, M. Am. Soc. C. E., the designer of the dam, I stated:

With the anchorage provided by the steel bolts, your dam would be safe against overturning, even with the assumed water pressure under its base, but it would not have a sufficient factor of safety against sliding.

Taking the coefficient of friction for masonry on masonry as 0.67 and allowing the shearing strength of the steel bolts as 60,000 lbs. per sq. in., the dam would have at its base a factor of safety of only 1.16 against sliding. With the comparatively smooth foundation on which the dam was built and which is very probably rendered wet by the water leaking from the reservoir, the coefficient of friction may easily be less than 0.67.

From the calculations which I made a year and a half ago, it was evident therefore that there was great danger of the dam's sliding. I think that all engineers who have examined the ruptured dam will agree that the failure was due to sliding.

Yours very truly,

E. Wegmann,
Consulting Engineer.

Park Row Building, New York City, Oct. 10, 1911.

Notes and Queries.

Moments in Continuous Beams.—A correction should be made in the formula for moments in continuous beams under partial loading, printed in Engineering News of Sept. 28, 1911, p. 380. The general expression for moment was printed:

$$M = -w_1 l_1^3 [\tfrac{1}{4} k_1^2 (2-k_1^2) - \tfrac{1}{4} c_1^2 (2-c_1)^2] - w_2 l_2^3 [\tfrac{1}{4} k_2^2 (2-k_2^2) - \tfrac{1}{4} c_2^2 (2-c^2)^2]$$

It should read:

$$M = -w^1 l_1^3 [\tfrac{1}{4} k_1^2 (2-k_1^2) - \tfrac{1}{4} c_1^2 (2-c_1^2)] - w_2 l_2^3 [\tfrac{1}{4} k_2^2 (2-k_2)^2 - \tfrac{1}{4} c_2^2 (2-c_2)^2]$$

The Tesla Steam Turbine.

A novel design of steam turbine was mentioned before a local meeting of the National Electric Light Association in New York City, on May 15, 1911, by Mr. Nikola Tesla, whose name has become famous in connection with the rotating magnetic field and other alternating-current developments. Several different types of power apparatus, both driving and driven, embodying the underlying principle of this turbine design have now been built and tested in the Tesla laboratories, including a turbine which has been running at the Waterside Station of the New York Edison Company for several months. The general results of this early work have recently been made public by Mr. Tesla.*

The following outline of the designs and the underlying principle running through them all has been made after a conversation with Mr. Tesla and a study of the apparatus. The fundamental principle underlying these several designs appears to be broadly applicable to apparatus wherein a fluid moves some device or the device causes the fluid to move. This includes hydraulic, steam and internal combustion motors, hydraulic and air pumps, etc.

The study of this most interesting line of designs may be approached through the case of either prime movers or driven devices. For the purposes of this article it is perhaps simpler to consider first a pump for a fluid like air, gas, vapor, or liquid. Fig. 1 shows, more or less diagrammatically, a rotary pump in which a series of smooth, flat disks revolves in a casing, with a volute delivery passage. The disks are fastened to a driving shaft but have central openings which serve as inlets for the fluid. On rotating the shaft and disks, the fluid film in contact with the disks is set in motion, even with perfectly smooth disks, on account of the molecular adhesion between disk and fluid. The fluid between disks is also dragged along by the molecular attraction between particles of the fluid (viscosity). The motion of each point of the disk being circular, it is evident that the particles of fluid receive impelling forces which are always tangential to the circular paths. The successive points on the disk that impel given particles of fluid are at increasing distances from the center. The fluid being mechanically unconstrained by walls or vanes except in an axial direction is free to travel in spiral paths from the axis to the periphery.

The fluid, in traversing the space from inlet to periphery, may follow a long spiral of several turns or a short one of part of a turn, depending on the quantity of fluid that is allowed to escape from the outlet. With unrestricted flow from the casing, there is little resistance to flow in a radial direction (that is from the backing up and development of pressure), and the tangential slip between disk and fluid is large. The pressure in the casing depends on the velocity with which the particles of fluid leave the periphery of the disk; the maximum pressure with the exit throttled is then proportional to the speed of the disks, the velocity head being converted to pressure head in the volute passage of the casing. The power absorbed is proportional to the square of the slip.

To one seeing such a piece of apparatus in action for the first time, the capacity of a small machine is surprising, especially in the absence of all vanes and projections of every sort which have heretofore been deemed necessary to force the fluid along. A moment's consideration, however, shows that the whole surface of each disk is effective in impelling the fluid along (solely by molecular drag), and the useful surfaces may be made very great in a machine of modest dimensions, in direct contrast with other analogous apparatus where only the relatively small area of buckets, blades, or other projections is effective.

Consideration also shows that any buckets or projecting parts that a disk might carry would constrain the fluid to travel in paths less natural or free, with the consequent development of impact and eddy friction which may be expected to decrease the efficiency over that of simple disks depending for their hold on the fluid only on natural molecular forces. In the case of the Tesla disks, the particles of fluid may be mentally pictured as rolling along on their spiral paths in orderly procession, held to the disks by some gravitation or force; whereas in the case of a disk with projections, the fluid would be pushed and crowded along by impact, with consequent disturbances.

It has been found, as theory would indicate, that the quantity of fluid discharged off the disks is proportional to the area of the disks; that is, the capacity of such machines increases nearly directly with their length along the shaft and about as the square of their diameter, the discrepancies arising naturally from the casing not having impelling surface but adding to the diameter and length of the machine.

The spacing of the disks in such a machine would depend on the conditions under which it had to operate—increasing with the viscosity and diameter and decreasing with the allowable slip. The aim of the designer would be to deliver the fluid from the disks at not much below peripheral speed under normal load conditions. When limitations of practical design would prevent the securing of desired pressures with one simple set of disks, the multiplication of stages is easily accomplished. The fluid then would pass from the exit passages of one stage to the inlet of a second, and so on.

The operations of a pump, as above described, are in general reversible for the production of power from a fluid moving with considerable velocity or under pressure. If a fluid under pressure, but of low velocity, enters the casing of the device shown in Fig. 1 in order to flow along the volute of decreasing cross-section and through the inter-disk spaces to what is now the outlet, it must constantly accelerate, converting its pressure head to velocity head. This moving fluid will exert a pull on the disks on account of molecular adhesion and viscosity. If the shaft were blocked so that it could not rotate, the particles of fluid would take short spiral paths from the volute to the outlet.

If the disks are allowed to rotate, however, the particles of fluid in contact with the disks would be subjected to a force preventing travel along the shortest spirals to the outlet. The resultant of the centrifugal force exerted by the disk and that coming from the velocity of the steam constrains the fluid then to follow a longer spiral path. This reminds one of the counter E. M. F. developed in the armature windings of an electric motor opposing the impressed voltage.

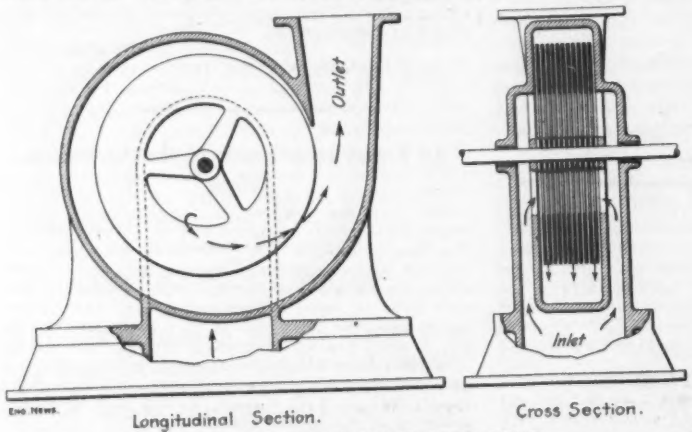
It is evident that the torque developed by the disk increases with the difference in peripheral velocity of the disk and of the fluid in contact. As in the analogous case of the pump, the torque rises as the square of the slip. When the shaft runs free, without load, the speed rises and the centrifugal counter force on the fluid, traveling in very long spirals (almost concentric circles), would cause the casing pressure to rise nearly to the supply pressure, the difference being only that required to do the work of supplying energy losses.

Such a prime mover would give its maximum output at about 50% average slip, but the maximum efficiency would come with a comparatively small slip, the actual figure depending upon the fluid employed, on the working conditions, and on the mechanical limitations of design.

The greatest interest in the Tesla design, as outlined above, probably centers in its application to a heat motor, such as the Tesla steam turbine. While a device like Fig. 1 would operate with steam, it probably would be advisable for obvious reasons to modify the mechanical features—for instance, to suppress the volute passage in the casing, coming down to the simple construction indicated in Fig. 2.

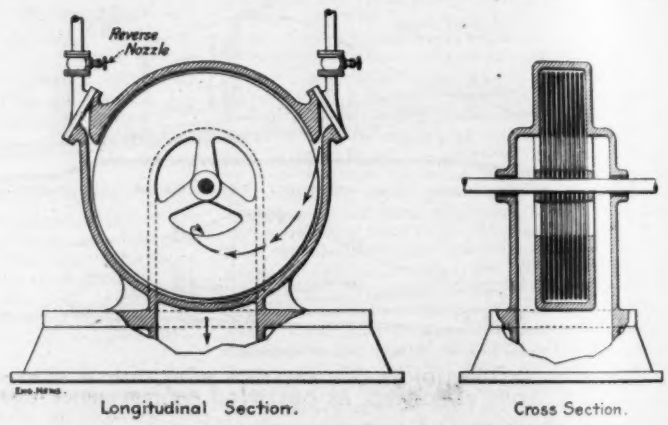
If the steam is expanded in a diverging nozzle, it may be expanded over any of the usual ranges of pressure drop, the heat energy then being converted into kinetic energy. The high velocity steam escaping from the nozzle is caused to impinge tangentially on the edges of the disks. In order to escape, it has to take a spiral path from the periphery of the disks to the center openings. The velocity energy of the steam is utilized through the molecular drag on the surface of the disks. With such a nozzle it is seen that the machine is essentially of the so-called "impulse" type of turbine. The arrangement shown in Fig. 2 has a very simple and convenient means of reversing, it merely being necessary to provide a duplicate nozzle discharging against the opposite diameter of the disks and in the opposite direction. When the machine is at rest or running slowly, as in starting, the steam takes a short path from the nozzle to the exhaust and develops a comparatively large torque, since this would be proportional to the square of the difference in velocity of steam and disk. As the machine speeds up, the difference in velocity between steam and disks decreases and the centrifugal forces tend to lengthen the spiral path, so that a given quantity of steam may make several revolutions before finally passing out the exhaust.

It is not necessary, however, to expand the steam before it reaches the disks, and in place



Longitudinal Section. Cross Section.

FIG. 1. THE TESLA DISK-IMPELLER PUMP.



Longitudinal Section. Cross Section.

FIG. 2. THE TESLA DISK WHEEL IN A STEAM TURBINE.

*For early statements of these developments see "Electrical Review and Western Electrician," Sept. 9 and 30, 1911; "The Scientific American," Sept. 30, 1911.

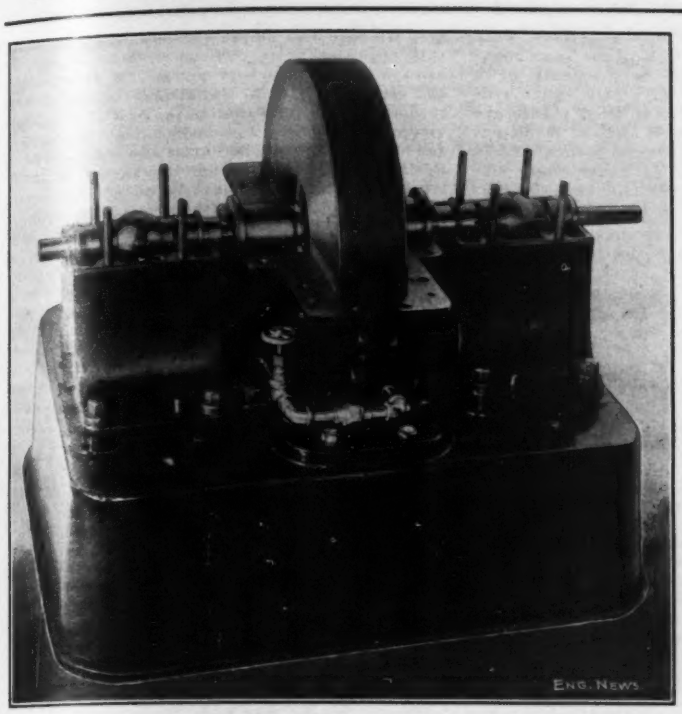


FIG. 3. A 200-HP TESLA TURBINE WITH THE UPPER CASING SECTION REMOVED.

of the nozzles shown there may be simple ports. The machine then apparently will operate as a reaction type of turbine, the steam expanding as it flows in its path from port to exhaust. The expanding steam might develop a slight reactive thrust against the disk, but it would depend probably more for its influence on the peculiar action of increasing the velocity of the steam in small increments as it flows along; and absorbing the kinetic energy as fast as developed, in driving the disk.

In Figs. 3 and 4, a steam turbine tested at the Waterside Station of the New York Edison Company is shown. The rotor consists of 25 disks, 18 inches in diameter. The assembled unit, Fig. 3, occupies a floor space some 20 × 35 ins. and it stands some 5 ft. high. The numerous gages seen in Fig. 3 were attached for test purposes. With steam at 125 lbs. gage and exhausting to atmosphere, 200 HP. was developed with a speed of 9,000 r. p. m. The steam consumption under these conditions was about 38 lbs. per HP.-hr.

Fig. 5. A 110-HP Tesla Steam Turbine.

Mr. Tesla states that with moderate superheat and the degree of vacuum ordinarily obtainable in a turbine plant, the consumption can be reduced to 10 or 12 lbs. per HP.-hr. The weight of the unit as shown was about 400 lbs., giving a unit weight of 2 lbs. per HP.

Through refinements in design in addition to the increase of capacity secured with superheat and vacuum, Mr. Tesla expects that the weight may be reduced to as little as ¼-lb. per HP. capacity and still allow of designs which will have rotational speeds low enough for direct connecting to the majority of services.

One of the interesting possibilities of the design of turbine shown is that of self-regulation. It has already been shown how the counter pressure due to the rotation of the disks amounted nearly to that of the impressed fluid when running idle. Since the centrifugal head increases as the square of the number of revolutions, and as with available materials great peripheral velocities of the disks are possible, a turbine may be designed which will not run away, the peripheral speed being limited to that value which corresponds to the maximum velocity of the fluid which can be developed.

The main principle of design may be use for an internal-combustion motor. The small machine shown in Fig. 5 has been operated with gaseous fuel burned in an auxiliary chamber and the products of combustion cooled by injecting steam or water spray. This gives a mixture of superheated steam and gases which leave the combustion chamber under high pressure, but reduced in temperature so that they may be led directly to the disks, serving in the place of steam from a boiler. The machine shown developed 110 HP., and it is stated that only the small sized shaft prevented pushing the load higher. The products of combustion instead of being cooled by the formation of superheated steam may be expanded in an insulated nozzle, the temperature falling with the reduction in pressure and the increase in velocity. At the exit of the nozzle, the temperature could be sufficiently reduced so that the gases could be caused to impinge on the disks without injuring them.

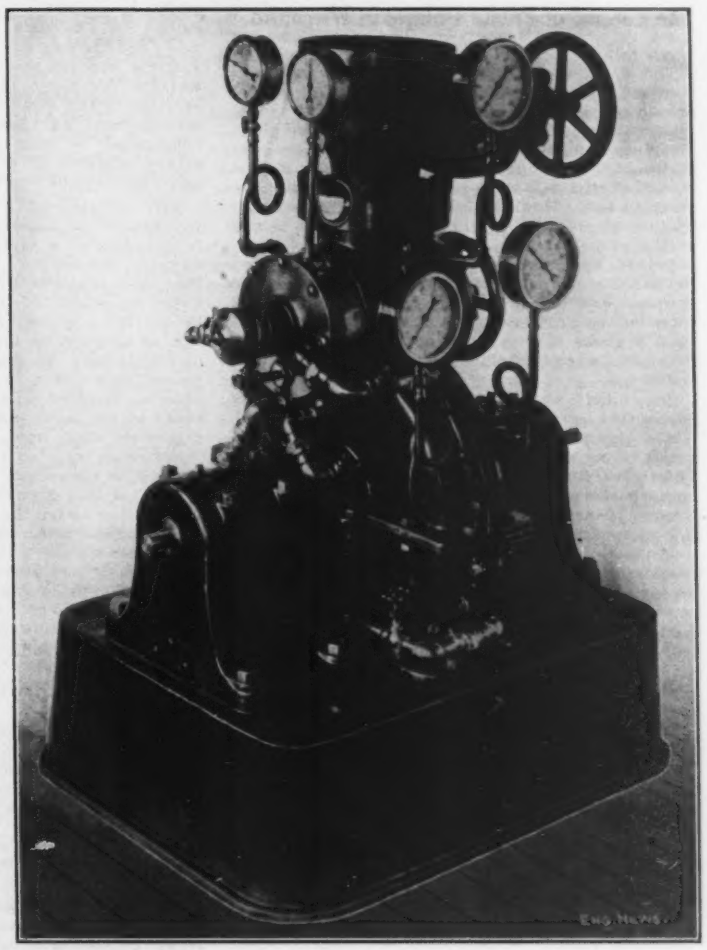


FIG. 4. A 200-HP TESLA STEAM TURBINE AS TESTED AT THE WATERSIDE STATION OF THE NEW YORK EDISON CO.

A Low Record Death Rate for New York City is reported by the local department of health for the nine months ending Sept. 30, 1911. The rate was 15.56 per 1,000 population against 16.27 for the corresponding period of 1910. A record was also made during the same period in lowness of infant mortality and in the number of deaths from diarrheal diseases of infants under one year of age. Notwithstanding the decline in the death rate for the first three-quarters of the current year, the total number of deaths was 58,144, or more than the total population of many of our thriving municipalities which consider themselves of no little importance.

The Appointment of Higher Municipal Officers by the Merit System is to be the topic of the Wm. H. Baldwin Prize Essay of $100 in a competition covering the university year 1911-12. Detailed information regarding the competition may be obtained from Mr. Clinton Rogers Woodruff, Secretary, National Municipal League, North American Bldg., Philadelphia. The following outline of the points which should be covered by essays submitted for this prize is of general interest as well as an appeal to those who may compete:

The appointment of higher municipal officers by the merit system involves a thorough discussion of (a) the reasons for the employment of experts in municipal work; (b) the proper position and tenure of the expert in the service of a city; his relation to the chief executive officer on the one side, and to the subordinate administrative forces on the other side; (c) the extent to which the merit system is applicable in the selection and retention of experts, and (d) a practical application of the conclusion reached by the essayist to some American municipality, showing the changes in organization and authority which would be required.

The competition is open to college students only.

The Control of Public Utilities in Wisconsin.*

By HON. F. C. McGOVERN.†

The basic legal principles underlying governmental regulation of public utilities, however novel may be their application to present industrial conditions, are as old as the common law. They are founded upon the very elementary distinction between a public and a private calling. One is clothed with a public use and interest, while the other is not. This public interest has always, in the eye of the law, justified regulation in behalf of the people as a whole. The nature and character of the business of utilities is such that competition is inoperative in determining service or rates, and the only choice left to the public is between regulated and unregulated monopoly. It goes without saying that the right of the state to supervise monopolies is as ancient as it is obvious.

But it may be urged that the exercise of this power, the enforcement of this right, is a legislative function which cannot lawfully be delegated to an administrative board or commission. This is very true; it does not, however, militate against the practical utility of commissions.

Most assuredly it is the Legislature and not the commission that has the power to regulate. It is the Legislature that does regulate. It is the Legislature that creates the commission, defines its powers, establishes rules for its guidance and determines the entire policy to be pursued. The commission merely ascertains the facts of each case as it is presented, and applies to these facts the law already laid down by the Legislature. It is purely an administrative body with administrative functions only, although these functions have become so immensely difficult and important that we sometimes conceive them to be either legislative or judicial in nature, or both.

The rule laid down by the Legislature is often a very simple and elementary one; in the case of Wisconsin utilities merely that the service and facilities furnished shall be reasonably adequate, and that the rates charged shall be reasonable and just. Manifestly the difficulty here is not in formulating a rule of action, but in applying it.

This relation of the commission to the Legislature and also to the courts is so well set forth in the recent case of the Minneapolis, St. Paul & Sault Ste. Marie Ry. Co. vs. the Railroad Commission of Wisconsin (136 Wis., 146), that I feel justified in quoting from the decision. Answering the objection that the law creating the Railroad Commission is invalid because it involves an unlawful delegation of legislative power, the Supreme Court of Wisconsin, in a very comprehensive and illuminating opinion, stated the law upon this subject as follows:

> In the process of enacting a law there is frequently necessary the preliminary determination of a fact or group of facts by the legislature, and it is well settled that the legislature may declare the general rule of law to be in force and take effect upon the subsequent establishment of the facts necessary to make it operative or to call for its application. . . . The legislature may delegate any power, not legislative, which it may itself rightfully exercise. This power to ascertain facts is such a power as may be delegated. . . . This law establishes, and thenceforth assumes, the existence of rates, charges, classifications and services, discoverable by investigation but undisclosed, which are exactly reasonable and just. It commits to the Railroad Commission the duty to ascertain and disclose that particular rate, charge, classification or service. The order of the commission is prima facie evidence that the rate, charge or service found and fixed by it is the particular rate, charge or service declared by the legislature in general terms to be lawful and to be in force.

An epoch-making decision, you will say; and in some respects it was. Contrasted with the holdings of some other courts the temper and attitude of the supreme bench of Wisconsin in this case was novel enough to be refreshing. As additional evidence of this, permit me to quote also the second last paragraph of this great opinion:

> The notion that commissions of this kind should be closely restricted by the courts, and that justice in our day can be had only in courts, is not conducive to the best results. Justice dwells with us as with the fathers; it is not exclusively the attribute of any office or class, it responds more rapidly to confidence than to criticism, and there is no reason why the members of the great Railroad Commission of this State should not develop and establish a system of rules and precedents as wise and beneficent within their sphere of action as those established by the early common-law judges. We find the statute well framed to bring this about.

The Wisconsin law makes no distinction between privately and publicly owned utilities. Both are amenable to the same regulations. Both report their financial conditions in the same manner, and according to the requirements of a uniform system of accounting. This seems reasonable, for the patrons of municipal plants are entitled to the same protection against inefficient management as those of private plants, and a comparison of results obtained under these different systems of owenership has been of real assistance in the regulation of both.

THE COMMISSION.—The commission created by this act is appointive, not elective; its members hold for a term of six years, and receive annual salaries of $5,000 each and expenses; they are required by law to be experts in the business committed to them, and are strictly forbidden from engaging in any other work or becoming interested directly or indirectly in any utility it may be their duty to supervise. Employed under them are about 100 clerks and engineers, some of whom receive salaries equal to those of the commissioners themselves. The engineering staff, upon which the members of the commission rely for all field and laboratory work as well as for expert and technical examinations, is divided into groups, each working along some special line under the direction of an experienced chief. These men, wherever possible, co-operate with the members and employees of the Tax Commission, and when convenient do their laboratory work in conjunction with the scientists at the University of Wisconsin. Thus organized and supported this staff is considered by many one of the most efficient ever organized for work of this kind.

THE INDETERMINATE PERMIT.—The mere fact of regulation of public utilities contains the implication that they are virtual monopolies; otherwise supervision of them might not be expedient or even justifiable. The Wisconsin statute goes farther and frankly recognizes this condition by providing for the so-called indeterminate permit. Considering that where effective regulation exists, competition is neither necessary nor desirable, the Wisconsin law provides that the short-lived franchise held by existing utility companies when it was enacted may be surrendered for indeterminte permits. This enabled the utility to secure a monopoly of the territory it occupied during good behavior, or until the plant should be acquired by the public at a fair valuation. In this way unnecessary duplication of equipment, unnecessary augmentation of fixed charges, and cut-throat competition are prevented, and a more economic and satisfactory service is secured. By doing away with short-time franchises, moreover, a speculative element is eliminated from public-utility investments, and the cost of financing enterprises of this sort is reduced.

Thus commission control is protective as well as regulatory—protective of the utility, I mean. The requirement that every person desiring to start a new utility shall first obtain from the Commission a certificate of public convenience and necessity further exemplifies this policy. In order that each existing company, so long as it properly serves the public, may be free from fear of invasion of its field by rivals, possibly more powerful than itself, it is provided that every utility having an indeterminate permit shall have an exclusive monopoly of the business in which it is engaged except in those rare cases where the Commission, after a hearing, may determine that public convenience and necessity require a second utility to divide the field or to supplement inadequate or defective service. "Sandbagging" and "paralleling" are thus very properly and effectively outlawed.

The last report of the Railroad Commission shows that 72 corporations, representing 37% of the gross earnings from utility business in Wisconsin, immediately upon this law going into effect, decided to exchange their franchises for indeterminate permits. Many others came in afterward. Stability in investments was thus obtained, as appears from the fact that the securities of utilities operating under a permit as a rule command a higher price in the market than those that operate under the old-time franchises. The period within which utilities might thus exchange limited-time franchises for indeterminate permits was at first definitely prescribed by the Legislature, then extended from time to time, and the last session made the indeterminate permit universal and compulsory. At present, therefore, there are no special franchises in Wisconsin.

STOCKS AND BONDS.—Another important feature of the Wisconsin law is control of stock and bond issues. The capitalization of utility companies is limited to the actual value of the property used in the public service. The reason for this requirement is obvious. Stock watering is always and everywhere an evil of far-reaching and especially baneful significance; but nowhere is it mort mischievious than in the case of public service corporations. Wisconsin has abolished it, so far at least as public utilities are concerned. Besides, experience teaches us that to be effective public regulation must be complete. It cannot be complete without control of the issue of corporate securities. In determining what is adequate service or a just rate, account must be taken in every case of the value of the plant. The value here spoken of is of course the actual, true value. There is no reason in the world why with complete control this value should not correspond with the stock and bond value, taking these securities at par. If so, control will be facilitated, the interests of inexperienced investors safeguarded, and the utility placed on a stable and conservative basis.

GENERAL PROCEDURE.—So much by way of the governing principles. A word now as to how this regulation is made effective. The procedure is extremely informal and simple. A letter addressed to the secretary of the Commission is usually sufficient to secure prompt investigation of the complaint and an adjustment of the difficulty. Many of the most important rate schedule disputes have been settled in this informal way. Extensive reduction in railway rates for coal, potatoes, grain and merchandise, and, in the utility cases, many improvements of service and reductions in rates, have been voluntarily made after an informal round-table conference. Where no such agreement can be reached a formal hearing is had, evidence received, and, if necessary, further investigation made, until the case has been determined upon all the facts and circumstances.

Every utility company must file with the Commission all rates, rules and regulations. No changes can be made in existing rates or schedules unless such changes have been approved by the Commission. Questions relating to service, rates and regulations may be investigated upon complaint of a customer or shipper, or the Commission may proceed to do so upon its own motion.

Should a court review of the order of the Commission be desired, the statute provides for a speedy hearing. The aggrieved party must begin his action within ninety days, and all such actions are given precedence over any civil cause of a different nature pending in court. Up to the present time only 17 orders of the Wisconsin Commission have been called in question in this way and in no case has any order been reversed.

RATES, SERVICE, VALUATION, ACCOUNTING.—It has been pointed out, by one of the Commissioners, that the most important provisions of the public-utilities law may be grouped under the four leading heads of rates, service, valuation and accounting.

The ascertainment in any case of what constitutes a fair and just rate is a most difficult problem. With rate-making indeed are associated most of the evils out of which the present insistent demand for public regulation has arisen. Discrimination, extortion, secret rebates, drawbacks and similar abuses—familiar as they all are—illustrate what I mean. The ordinary citizen is entitled to protection against them.

What now is the basis of a just, equitable rate? Some railway managers and superintendents of public-utility plants contend that it is the value of the service to the shipper and consumer. But this method of fixing rates at "what the traffic will bear" has become so odious and is so manifestly a cloak merely for extortion, discrimination and favoritism that extended discussion of it is no longer profitable. It involves so many elements, some subjective and some objective, and so varies with differences in person, time, place, commodities and other conditions as to afford really no scientific basis whatever for rate-making. Entirely aside from its whimsicality and the favoritism it invites, it is too indefinite and uncertain to be formulated into a workable basis for rate-making in even a majority of cases. Practically every commission, legislature and court which has seriously considered the subject has rejected this criterion for the more definite and scientific idea of the cost of service. The basis is definite, fair, ascertainable and economically justifiable. It bears the same relation to rates that the cost of production does to the price of commodities; and just as the cost of production of wares and merchandise determines their normal value, which market price constantly approximates but with which it seldom coincides, so the cost of service rendered by public

*Extracts from an address before the 1911 Conference of Governors, Spring Lake, N. J., Sept. 14.

†Governor of Wisconsin, Madison, Wis.

utilities determines normal rates toward which actual schedules should steadily be made to approach.

How now may the cost of service in a given case be ascertained? First of all, the owners of utilities are entitled to a fair return upon the reasonable value of the property devoted to public use. This calls at once for a valuation of the physical property of the plant. But this is not all. To it must be added something for the "going value" of an established concern and possibly something else for outlays and services expended in the past in upbuilding the plant.

The Wisconsin law requires the Commission to value "all the physical property" and "all the property used and useful for the convenience of the public" belonging to every public utility in the State. As there are more than a thousand of these plants and the Commission has appraised only about one hundred, it is evident that this is work that cannot be quickly dispatched. But it should be understood that among the one hundred valuations made are included all the steam railroads, the Milwaukee Electric Railway & Light Co., and many of the more important among the minor utilities of the State. Indicative of how well this work has been done lies in the fact that no appeal has ever been taken, either by a utility or a municipality, from any valuation made by the Commission. In some instances the utilities admitted that the inventories prepared by the Commission were the best that had ever been taken.

But the value of the plant is not the only factor—though it may be the chief one—entering into the determination of equitable rates. Expense of operation, depreciation and other similar items must also be considered. And after there has been a determination of the gross charge necessary for the maintenance of the utility and the payment of reasonable profits to its owners there yet remains the apportionment of this amount among the various classes of consumers. In the case of electric lighting, for example, the flat-rate-per-lamp rule which prevailed almost universally in Wisconsin before public regulation began, was soon found to be very unjust and unsatisfactory. To say nothing of the manifest unfairness of this arrangement, waste of electricity was of course the natural result with consequent loss to both producer and consumer. Similarly the straight-meter rate normally imposes an unequal burden upon long and short-hour consumers. The proper adjustment of matters of this sort, though by no means simple, is nevertheless possible and highly desirable. It is of the very essence of scientific rate-making, for without it justice between different classes of consumers is impossible of attainment. Hence the necessity of proper accounting.

With accurate information as to the value of the plant and proper distribution of the cost of service according to modern systems of accounting it is possible to make rate schedules that are equitable to all classes of consumers, that yield a reasonable rate on the investment and that eliminate waste while promoting the maximum usefulness of the plant.

When the Wisconsin act went into effect, therefore, the Commission called upon the utilities to submit a statement of their financial condition. The naivete of the response has been so well described by Mr. F. L. Holmes, of Madison, that I take the liberty of quoting from his account of it.

> The returns were both amazing and amusing. Some companies kept books, the accounts of others were mere memoranda or check-book stubs which mean nothing. The bookkeeping affairs of one municipal plant were recorded in a vest-pocket account book, tied with a woolen string. Often the owner and manager carried the affairs of the corporation in his head. Few plants carried a depreciation account, and fewer managers understood the purpose of such a fund. Where several utilities had been merged, one general account was maintained for credit and another for debit. Business system was unknown. A majority of municipal plants received no credit for the service rendered the city. The revenue went into the general fund and when there was an expense the city made an appropriation. Often city employees attended to the detail labor of the plant, but the salary for services was paid out of the general fund.

As required by law, the Commission put an end to this rule-of-thumb work and prescribed a uniform system of cost accounting for all the utilities of the state. The result was most gratifying. By introducing system where chaos reigned and compelling uniformity, both public and private plants were placed upon a basis of efficiency and economy, and an enduring foundation was laid for intelligent future supervision. It should be some satisfaction to the Commission to know that its classification of accounts has since been voluntarily adopted by utilities in other States, in Canada, and even in Mexico.

The subject of service is closely related to that of rates. A just determination of what constitutes reasonably adequate service in any given case depends primarily upon a correct valuation and a satisfactory system of cost accounting. In addition, it requires an inspectional staff. Gas, electric, water and telephone service have received special attention at the hands of the Wisconsin Commission and requirements as to them have been standardized. These standards so far as gas and electric service are concerned were embodied in a set of rules adopted only after a most careful survey of actual conditions, both within the state and throughout the country. They cover such matters as the heating value and purity of gas, voltage, care of lamps, accuracy of meters, disturbance in electric circuits, and similar matters. The staff of field inspection charged with the administration of these rules are selected with particular reference to their previous technical training and experience in the lighting business. Their visits to the various plants are unannounced and vary in frequency from one to four or five times a year as the conditions may require. Immediately after the promulgation of these rules there was a marked improvement in the character of service.

RESULTS OF REGULATION.—It is interesting to contrast the predictions of disaster made by the opponents of railway and public-utility regulation with the actual results of the operation of these laws. "Radical," "populistic," "revolutionary," were some of the mildest terms used. It was pointed out that the entire country and especially the State of Wisconsin had prospered under the laissez faire regime of earlier days, and it was said that any such restriction of commercial liberty as these laws proposed would result in a system of bureaucratic control which must inevitably disorganize business and destroy prosperity.

In striking contrast to these lugubrious forecasts stand the actual results of commission control. Most emphatically has it been a good thing not only for the public but for the utilities also. The public has made an immense financial gain; just how much it is difficult to state with entire accuracy, for many orders of the commission concerning rates lowered some and raised others. But it has been conservatively estimated that in the matter of freight rates alone there has been an average annual saving of at least $1,200,000; in passenger fares of not less than $800,000, and in other forms of public service a proportionately large amount.

This, of course, is not all clear gain. The commission has done a great deal of work, most of it of an expensive sort, and this cost has been borne in large part by the public. In the regulation of railway rates it has been necessary to separate state from interstate traffic, freight from passenger service, and to apportion the gross cost of transporting freight among the various commodities and classes of merchandise submitted for shipment. Substantially the same sort of analysis and discrimination has been necessary in the case of the other utilities. It is work that calls for a very high order of ability and expert training. In round figures, the cost of maintenance of the commission, including the expense of hearings, of furnishing transcripts of the proceedings free of charge to all interested parties, of appraisals, of publications and of service and accounting inspections, is about $100,000 a year.

A large outlay, an expensive commission you will say; but in view of the fact that the railroads and other utilities are invariably represented at every important hearing by the very ablest engineers and experts, the State cannot afford to indulge in cheap or short-sighted economy; and after all, when the saving effected runs into millions of dollars each year the people can afford to pay out even $100,000 a year for expenses.

Hereafter at the prescribed rate of $1 for each $1,000 of the face value of corporate securities thus issued, the revenue derived from the operation of the stock and bond provision alone will in all probability be sufficient to defray the entire cost of the commission.

Hand in hand with reduction in rates has gone an equally important improvement in service. Better service has even been placed first and reduction in rates made to wait upon it. Transportation facilities have been vastly improved; new stations have been built as ordered by the commission; cleanliness and sanitary precautions have been observed as never before; closed connections have been made at junction points, and more and better trains have been provided. And also of express, lighting, telephone and telegraph service; they have all responded to the demand for a higher standard of efficiency in numerous ways, more forcibly felt and plainly evident than it is possible for us briefly to describe.

The genuinely constructive and enduring character of this method of control is best demonstrated, however, by the fact that while the people have thus gained enormously, the utilities have not suffered. On the contrary, under this system they have prospered as never before. Lower rates have not been followed by diminished income, but by inviting larger patronage have resulted instead in an actual increase in revenues. To the utilities, therefore, the net outcome has been a gain.

As evidence of the prosperity under commission regulation the last annual report of the Wisconsin Commission shows that during the year the operating revenues of electric utilities increased 20%, their net income 29%, and new construction for the year 145%. The operating revenues of water utilities meanwhile increased 7%, their income 13%, and the new construction 24%. Gas utilities increased their operating revenue 3%, their net income 15%, and new construction 24%. Telephone utilities increased their operating revenue 11%, their net income 9%, and construction for the year 14%. Railway and traction lines on the average increased their operating revenues 13%, their net income 8%, and construction an equal amount. All utilities in Wisconsin are in a more flourishing condition now than ever before and are planning to extend their operations far into the future.

Taking a longer period, as we may in the case of railway regulation, which was begun earlier, the results are even more striking. For the fiscal year ended June 30, 1905, the total mileage of railroads in Wisconsin was 6,931 and the total operating revenue $50,144,702.43. This was the year immediately before commission regulation of railroads began. Five years later, or during the fiscal year ended June 30, 1910, the total mileage had increased to 7,209, an increase of 278 miles, and the total operating revenues amounted to $65,055,928.76, an increase of nearly $15,000,000. Thus, notwithstanding the decrease in transportation rates and improvement in service enforced by the Railroad Commission, the operating revenues of the railroads of Wisconsin increased approximately 30%.

As an indication of the general prosperity of the State meanwhile it may be worth mentioning that under these new policies the deposits in commercial and savings banks in Wisconsin increased in round numbers during this five years from $187,000,000 to $276,000,000, or 51%.

How these results are possible may be illustrated by the case of the Madison Gas and Electric Company,* which in this respect may be considered fairly typical. In March, 1910, this company's schedule of rates based as it was entirely upon the energy consumed, was abolished and there was substituted a new schedule which took into consideration the elements of amount of installation and classes of consumers, as well as the amount of energy used.

After one year's operation of the new schedule another investigation was made, and it was found that compared with 1909, the last current year in which the old rates were in effect, the output of the electric plant had increased over 16%, the gross earnings nearly 13%, the net earnings 24% while expenses increased less than 3%. Compared with 1907, the number of consumers in the residence class had increased 34%, the number of lamps connected 54%, the kilowatt-hours sold 70%, and revenue 35%. Here, however, is the important point; after a year's operation under the commission's schedule it was found that the business had so increased that it was possible to effect a further reduction in the primary rate of 2 cts. per KW.-hr. and make a net cut in the revenue of the company of $24,000.

Not only have rates been lowered as a whole to the advantage of both the people and the utilities but discrimination among patrons has been abolished. Nothing could be more desirable.

When the Wisconsin law went into effect it was estimated that discrimination and rebates to favored customers of telephone, water, heat and light companies amounted to as much as $2,000,000 annually. Even as late as August, 1909, 52% of the telephone companies, 60% of the water plants, 35% of the gas companies and 58% of the electric lines admitted they still maintained discriminatory rates.

Since then there has been a change. All

*See Eng. News, March 31, 1910, p. 380.

schedules and rates are now on file with the commission and these are the only rates that can be collected. Discrimination is absolutely forbidden and the law in this respect is well obeyed. The effect of this change upon industrial and commercial enterprise and the elevation in moral tone of the communities where these abuses formerly existed cannot easily be exaggerated. Peace, contentment and self-respect have taken the place of suspicion, injustice and guerrila warfare.

Times were in Wisconsin when the railroads ran or tried to run the government of the state and the minor utilities frequently sought to boss the cities, towns and even villages. They contributed liberally to campaign funds, urged their supporters and lobbyists to become candidates for public office and in close election districts colonized voters in the old conventional way. Now, one and all, they are in this sense absolutely out of politics. There is indeed no reason now why public-service corporations in Wisconsin should wish to dabble in public affairs. Their relations to the people of the state have been definitely and finally determined. They no longer have anything to gain or lose by intermeddling in politics and apparently they have decided to retire for good. What the elimination of public-service corporations from participation in political campaigns signifies in the purification of public life no one here needs to be reminded.

The operation of the stock and bond law, the indeterminate-permit provision and other cognate requirements of the public-utilities law have encouraged investments in the securities issued by these corporations. Most gratifying of all is the recent tendency toward local investment in these securities and consequent local support of the utilities. The natural result is the establishment of better and friendlier relations between the utilities and the public. That the operation of the Wisconsin law has brought additional stability to investments of this sort is shown by the fact that practically every trust company and dealer in stocks and bonds engaged in selling the securities of plants located in Wisconsin advertise regularly in the financial journals the fact that these securities are issued under state regulation. The whole tendency of commission control is to remove public-utility securities from the field of speculation and place them upon the solid basis of conservative and stable investments.

Such in brief are the principal features of the system of state control of public-utilities as it is practised in Wisconsin. A product of constructive legislation somewhat novel in conception, it has nevertheless worked admirably. It is comprehensive, effective, prompt and progressive —a demonstrated practical success. It proceeds upon the theory that these corporations are the servants, not the masters, of the people. As servants it has protected, encouraged and instructed them in all matters of economy and efficiency just as it has summarily suppressed all assumption on their part to the role of masters. But in relentlessly enforcing fairness to the people it has not forgotten to be fair to the utilities. It has made the monopoly of each company within its appropriate field even more secure than it was before. It has systematized methods of accounting and so given to the most backward the advantages of the very latest improvements in management: By control of stock and bond issues it excludes opportunity for wild-cat speculation and the altogether too familiar methods of "frenzied finance." It compels the maintenance of each utility at the point of maximum efficiency and so safeguards legitimate investment. While protecting the citizen against extortionate rates and inadequate service, it insures to capital a reasonable return and to labor a fair wage. In a word, it has transformed what were formerly speculative ventures bent on exploiting the public into safe and conservative business establishments operated for the benefit and convenience of all.

A Carborundum-Lined Pump is now made for handling gritty water. The latest improvement to the Pulsometer pump is the addition by a patented process of an abrasive metal lining to the regular form of cast-iron shell. It is claimed by the manufacturers that sand-blast and other abrasive tests seem to indicate that this lining will stand up well under very severe conditions, and add in a considerable degree to the length of life of a pump handling gritty water at high velocities. This pump is made by the Pulsometer Steam Pump Co., 17 Battery Place, New York City. This seems to mark the beginning of a development in the use of carborundum similar to that which was noted for another abrasive, alundum, in Engineering News, June 8, 1911, p. 691.

Destruction of Two Earth Dams by Overtopping; Flood at Black River Falls, Wis.

Heavy rains in western Wisconsin last week brought about the failure through overtopping of an earth and concrete dam on the Black River at Dells on Oct. 6. The mass of water discharged from this dam overtopped and washed out a larger earth and concrete dam at Hatfield, 6 miles below. The flood wave below the Hatfield dam was strong enough to devastate the bottom land at Black River Falls, 12 miles downstream, and cut into a hill on which stood the business section of the town. The entire business district, comprising 50 buildings, was wrecked. The damage at Black River Falls is at least $1,000,000, according to the estimate of Mayor McGillivray. The warning telephoned down the river from Dells gave enough time for all persons to gain a place of safety, and so far as yet reported no lives were lost.

At our request, Prof. W. D. Pence, of the University of Wisconsin, Madison, Wis., went to the site of the broken dams immediately after the disaster. His telegraphic report follows:

Merrillan, Wis., Oct. 9.

Two dams owned by the Lacrosse Water Power Co. and located on Black River, one at Hatfield, Wis., and the other at the Dells, six miles above, failed due to overtopping of earthwork dikes immediately after heavy rains lasting 18 hours, with a precipitation of about 3 ins. in that time.

The failure of the upper dam occurred about 6 a. m., Friday, Oct. 6, after prolonged effort by a large force of men to keep the crest of the dike above the rising water. At the time the dike gave way, the water had risen to a height of 7 ft. or more above the crest of the concrete spillway. Within 40 minutes after water broke over the dike located at the west end of the dam, the earthwork was carried away and its concrete core-wall overturned, leaving a gap of 400 ft. The easterly end of the concrete dam, containing gates and spillway, was left intact.

At the Hatfield dam the water had reached a somewhat threatening stage at 3 p. m., Thursday, Oct. 5, at which time all flashboards were removed. Heavy rains through Thursday night brought the water to a critical stage before the peak of the wave from the Dells dam reached Hatfield—about 8 a. m., Friday. When this wave arrived, water immediately broke over the wing-wall just west of the gate-house at the extreme west end of the concrete dam, and quickly eroded the earth dike for a distance of upwards of 100 ft. beyond the end of the core-wall. At practically the same moment water also broke over the crest of the earth embankment near the eastern end of the dam, washing earth from top and downstream side of core-wall, overturning the same for a distance of 500 ft., and scouring to bed rock, 20 ft. deep. Here also the main concrete dam, resting on granite bed rock, remained intact. The embankment of the Green Bay & Western Ry., immediately downstream and parallel, was washed out for a distance of 500 ft. The flow from the breach at the west end broke into the canal leading to the power station, 2½ miles below. Prompt action in cutting the bank to give outlet into the river saved both the canal and the power house from destruction.

The rush of water following the failure of the Hatfield dam reached the city of Black River Falls, 12 miles below, about 10 a. m. At this place a low concrete dam owned by the city deflected the flow sharply against the toe of a high sandy bank, upon and adjoining which was located the main business district. In the course of a few hours some 50 buildings, comprising the business section, covering nine acres, had completely disappeared in the newly formed river bed. There was no loss of life, because of vigilance on the part of the company superintendent at Dells, who notified the local officials by telephone.

W. D. Pence.

Production of Alloy Steels has been investigated by the American Iron and Steel Association, which published in July last the following statistics of the tonnage of steel treated with various alloys during 1910:

Titanium steel	326,316	gross tons.
Nickel steel	106,707	" "
Nickel-chrome steel	52,021	" "
Chrome steel	23,550	" "
Manganese steel	19,360	" "
Vanadium steel	9,049	" "
Other alloys	30,816	" "
Total	567,819	" "

An International Movement to Conserve the Purity of the Water of the Great Lakes.

During the last few years a number of city health officers and other public-spirited sanitarians have bestirred themselves to secure at least a reasonable degree of state or federal control of the discharge of sewage into the Great Lakes. One of these movements has centered at Chicago and another at Buffalo. On Sept. 29, 1911, an international movement to the same general end was set on foot. On that date some 45 representatives from various cities in the United States and Canada and from state health departments of the states bordering on the Great Lakes met and formed the Great Lakes International Pure Water Association.

We have received from Mr. R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health, Columbus, Ohio, the following account of the general plan of the Association, so far as yet outlined:

The Association is to consist of two classes of membership, official and non-official. The latter is to comprise any person interested in the preservation of the purity of the water of the Great Lakes, and the former, or official members, are to be as follows:

A representative from the U. S. Public Health Marine Hospital Service.

A representative from the U. S. War Department.

Two representatives from the National Government of Canada to correspond to the above two from the U. S. Federal Government.

Two representatives from each of the eight states and two provinces surrounding the Great Lakes; one of these to be appointed by the Governor or Premier, and the other to be appointed by the state or provincial health department.

Representatives to be appointed by the Mayor of each city or town surrounding the Great Lakes on the basis of one representative for each 200,000 population or fraction thereof.

The total official membership will be approximately sixty, provided all the above officials respond by appointing a representative.

At the meeting on Sept. 29, it was decided that the executive committee should be composed of the four officers of the Association, or the president, vice-president, secretary-treasurer and editor, together with one other official member. The following officers were elected:

Dr. C. E. Ford, President, Superintendent of Health, Cleveland, Ohio.
Dr. C. J. Hastings, Vice-President, Health Officer, Toronto, Canada.
Prof. Ed. Bartow, Secretary-Treasurer, Director State Water Survey, Urbana, Ill.
Dr. W. A. Evans, Editor, late Commissioner of Health, Chicago, Ill.
Prof. R. G. Perkins, Member Executive Committee, Professor of Hygiene, Western Reserve University, Cleveland, Ohio.

There were also appointed sub-committees on constitution and by-laws on compilation of existing laws; and upon scope of investigation. The latter committee, which will report regarding the necessary investigations to be made and general line of work to be pursued by the Association, is composed of the following:

Prof. R. G. Perkins (as above).
R. Winthrop Pratt, M. Am. Soc. C. E., Chief Engineer, Ohio State Board of Health, Columbus, Ohio.
Langdon Pearse, Assoc. M. Am. Soc. C. E., Engineer-in-Charge Sewage Testing Station, Sanitary District, Chicago, Ill.
Dr. J. A. Amyot, Director of Hygienic Laboratories, Toronto, Canada.

It is expected that there will be another meeting in a few months hence at the call of the executive committee.

A Cave-in at a Construction Camp on the Canadian Northwestern Ry., near Colwood, B. C., Oct. 9, killed ten men.

An Explosion of Dynamite, Oct, 9, in the Lewis mine, near Telluride, Colo., wrecked the shaft and entombed 40 of the miners. Reports state that the explosion was caused by a fire.

An Electric Railway Wreck at Rochester, Mich., Oct. 7, is reported to have caused the death of eleven people. A passenger car and a work car on the line operated by the Detroit United Rys. Co. met in a butting collision.

An Explosion on the Catskill Aqueduct Work, in West Drive, Central Park, New York City, Oct. 9, killed four men and injured six others. The accident is ascribed to an unexploded charge of dynamite that was struck by a rock drill shortly after work was begun Monday morning. The

men were at work on a shaft which is to be sunk about 200 ft. for the aqueduct tunnel. The contractor in charge of the work was the Dravo Construction Co., of Pittsburgh, Pa.

A Mine Cave-in, Oct. 3, at the Drifton No. 2 colliery of the Lehigh Valley Coal Co., near Freeland, Pa., buried seven miners, of whom five were killed. According to press reports, the cave-in was the result of the collapse of a wooden stack which connected with an abandoned air shaft, rising up from the shaft through a large culm bank. The men were engaged in repairing a cableway that conveys mine refuse from the breaker to the culm bank.

Excavation on the Panama Canal during September amounted to 2,538,764 cu. yds. place measurement, as compared with 2,706,223 cu. yds. in the previous month, according to a cablegram received at Washington from the Chief Engineer on the Isthmus. There were 25 working days in September, against 27 in August, while the September rainfall was 6.35 ins. as compared with 7.79 ins. in August. The daily average for September was 101,551 cu. yds., while in August it was 100,230 cu. yds.

The amount of concrete laid during September was 132,410 cu. yds., which is less by more than 17,000 cu. yds. than that laid in August. The amount of fill placed in dams in September was also less than in August, being 501,276 cu. yds., as compared with 613,830 cu. yds. in the previous month.

The International Balloon Race for the James Gordon Bennett trophy and the Lahm cup, which started from Kansas City on Oct. 6, was won by the German balloon Berlin II. The distance covered is reported as 460 miles, from Kansas City to a place about seven miles northeast of Holcombe, Wis. The nearest competitor landed at Millston, Wis., a distance of 365 miles from Kansas City. All records were much behind those of the international races of last year, owing to unfavorable weather conditions.

Loss of Life in the Austin Flood is now estimated at about 75. Over 60 bodies have been recovered. Work at clearing away the debris of wrecked houses, etc., is going on very actively. The Pennsylvania Health Commissioner, Dr. Samuel G. Dixon, has been in charge at Austin since the day after the dam failure, and with his Chief Engineer, F. Herbert Snow, M. Am. Soc. C. E., has taken general care of sanitary matters in addition to directing the temporary housing and feeding, etc. The State Water-Supply Commission has had its engineer, Farley Gannett, M. Am. Soc. C. E., on the ground making a full study of the accident.

An inquest into the dam failure was begun by the District Attorney of Potter County, before a Justice sitting as Coroner. Mr. Frederick Hamlin, the Austin superintendent for the Bayless Paper & Pulp Co., declined to answer questions at the inquest by advice of counsel on the ground that answers might tend to incriminate him. Earlier in the week reporters interviewing Mrs. Hamlin had learned that her husband on past occasions expressed a general fear of the dam, refusing to move from a hillside house to a house in town on the bottom land because the former would be more safe if the dam should ever break.

A Joint Water-Supply Scheme for Paterson, Montclair, Glen Ridge, East Orange, Newark, Elizabeth, Nutley and Totowa, N. J., has been reported on, with plans and estimates, by Mr. Morris R. Sherrerd, M. Am. Soc. C. E., Consulting Engineer to the State Water Supply Commission of New Jersey. The Commission named has approved the report and a conference of the municipalities and the Commission has been called for Oct. 24, 1911, to be held at the City Hall, Newark, at 2 p. m. This action has been taken in accordance with Chapter 303, of the 1910 Laws of New Jersey, under which the municipalities applied to the Commission to make the investigation and report. The plans submitted by Mr. Sherrerd include an eleven billion gallon storage reservoir on the Wanaque River, near Midvale, N. J., with a flow line 275 ft. above sea level, and a 72-in. steel pipe line with a daily capacity of 50,000,000 gals. to Paterson, a 60-in. steel pipe line with a capacity of 30,000,000 gals. thence to Newark, and a 48-in. steel pipe of 15,000,000 gals. capacity thence to Elizabeth. The estimated cost of this supply is $5,862,000. Estimates have also been made for a high-level supply of 15,000,000 gals. daily from Greenwood Lake, to serve elevated territory in Montclair, Glen Ridge, Bloomfield, Nutley and East Orange, with deliveries at elevations from 510 to 487½ ft. The estimated cost of this supply, which includes small items for an intake dam and for right-of-way, and 170,000 ft. of 48-in. steel pipe, is $3,428,750. The total capital, operating and maintenance charges are estimated at $25 per 1,000,000 gals. for the 50,000,000-gal. low-level plan and $43 for the 15,000,000-gal. high-level plan. Mr. Sherrerd states that the Pequannock gravity supply now costs Newark $36 per 1,000,000 gals. delivered into the reservoirs within the city limits, and that most of this is for interest and sinking fund charges. The act already cited authorizes municipalities to contract with the Commission for a supply of the general character just outlined and to advance to the Commission $30,000 per 1,000,000 gals. of daily capacity desired. It will be understood that none of the municipalities mentioned is yet committed to the scheme, and that some of them would have to acquire water distribution systems owned by private companies before going into the project.

Mechanical Water Filters have been much slower in their introduction in England than in the United States, but altogether a number of British municipalities are now making use of mechanical filtration. In some, but not all, cases the mechanical filters are supplementary or complementary to other processes of treatment. According to "The Surveying and Housing World" (London, Sept. 23, 1911), the City of Sheffield, England, has just let a contract for mechanical filters with a total capacity of 7,200,000 U. S. gals. per day. These filters will treat a portion of the water-supply of Sheffield, which comes from the Loxley Valley. This supply is characterized by our contemporary as "comparatively pure," and apparently it is a surface supply from impounding reservoirs. The filters will be of the pressure type, 32 in number, housed in a building about 70 × 105 ft. in length, and will be supplied by Mather & Platt, of Manchester, England.

Preserving Railroad Ties by immersing in Great Salt Lake, Utah, is being tried by the Southern Pacific Co., according to a press report. It is stated that 10,000 ties which have been immersed in the lake for the last three years are now being transported to Hazen, Nev., to be laid on the new Hazen cut-off. It is stated that ties impregnated with the salts of this lake show great durability when laid in the arid region where the salt will not be washed out.

The Commission Plan of City Government was recently adopted at Gardiner, Me., by a vote of 723 to 181. In place of the present six aldermen and 18 councilmen, there will be three commissioners. Two of the commissioners will receive $1,000 a year and the third commissioner, or the one selected as mayor, will be paid $1,200 a year. The commission plan of city government was recently adopted at both Ridgewood and Irvington, N. J., but was voted down at Rahway, N. J.

The Pan-American Railway Project is brought occasionally to public notice as a future route between New York and Buenos Aires, but we have pointed out before that such a railway would be simply a series of local lines and would have little or no significance as a trade route. A list of the portions now completed has been published recently in the "South Pacific Mail," and this is summarized below, but it must be borne in mind that the lines have different widths of gage and have not been built as parts of a through route. Consequently the location is very indirect and the construction is not that of a main-traffic railway:

	Miles.
New York to Mexico City (completed)	3,026
Mexico to Guatemala frontier (completed)	843
Guatemala to Panama Canal Zone (508 completed)	1,053
Canal Zone to Puno, Peru (542 completed)	3,362
Puno to Guaqui, Bolivio (by water)	102
Guaqui to Quiaca, Argentina (363 completed, 167 under construction)	530
Quiaca to Buenos Aires (completed)	1,060
Total distance	10,006
Total distance completed	6,611
Total distance to be built	3,395

Personals.

Mr. R. B. Kittridge has been appointed Instructor in Civil Engineering at the University of Maine.

Mr. Hasbrouck Haynes, of New York City, was married on Oct. 7 to Miss Louise Covington, of Richmond, Ky.

Mr. A. T. Childs, Assoc. Am. Inst. E. E., has been appointed Assistant Professor of Electrical Engineering at the University of Maine.

Mr. Frank C. Wight, Associate Editor of Engineering News, was married on Oct. 5 in Brooklyn, N. Y., to Miss Julia Theodora Welles, a graduate of Adelphi College, Brooklyn, class of 1907.

Dr. Herman von Schrenk, Assoc. Am. Soc. C. E., formerly Supervisor of Timber Preservation, Frisco-Rock Island Ry. System, has been appointed Consulting Timber Engineer of the same railways.

Mr. Theodore P. Shonts, of New York City, has resigned as President of the Minneapolis & St. Louis and Iowa Central Rys. He is succeeded by Mr. Newman Erb, former President of the Wisconsin Central Ry.

Mr. M. K. McCay has resigned as President of the McCay Engineering Co., Baltimore, Md., to become City Engineer of Baltimore. He will retain his connections with the McCay Engineering Co. as consulting engineer.

Mr. Charles H. Moore, M. Am. Soc. C. E., formerly Engineer of Grade Crossings, Erie R. R., and Consulting Engineer of the Ferro-Carril al Curaray, of Ecuador, has been appointed Principal Assistant Engineer of the Erie R. R.

Mr. Mason B. Starring, President of the Chicago & Oak Park Elevated R. R., and formerly President of the Northwestern Elevated R. R., of Chicago, Ill., has been elected President of the United Railways Investment Co., of New York City.

Mr. James A. Roosevelt, General Superintendent of the Third Ave. R. R., New York City, has been selected to manage the electric railway properties of the British Columbia Co., with headquarters at Vancouver, B. C. Mr. Roosevelt is a cousin of Col. Theodore Roosevelt.

Mr. D. S. Hooker has been appointed Chief Engineer of the Wichita Falls & Northwestern and Wichita Falls & Southern Rys., succeeding Mr. R. A. Thompson, M. Am. Soc. C. E., whose appointment as Railway Commissioner of California was noted in our issue of Sept. 7.

Mr. Alexander R. McKim, M. Am. Soc. C. E., Consulting Engineer, of New York City, has been appointed by the New York State Conservation Commission to investigate and report upon the safety of dams for water power and reservoir purposes within the State of New York, at a salary of $3,500 per annum.

Mr. Wm. R. Copeland, whose acceptance of a position with the Metropolitan Sewerage Commission of New York was noted in these columns in our issue of Oct. 5, should have been reported as in charge of the bacterial laboratory of the Lawrence Experiment Station for a year, instead of "in general charge" of the station from 1893 to 1897.

Mr. H. W. Stanley, formerly Superintendent of Traffic of the Seaboard Air Line Ry., has been promoted to Assistant General Manager of the same. The position formerly filled by him will be taken by Mr. J. M. Shea, formerly Division Superintendent at Atlanta, Ga. Mr. George Carlton, formerly Trainmaster at Jacksonville, Fla., succeeds Mr. Shea at Atlanta.

Mr. R. H. Thomson, M. Am. Soc. C. E., City Engineer of Seattle, Wash., has been appointed Port Engineer of the Port of Seattle in addition to his present duties. The administration of the harbor has been placed in the hands of three commissioners elected on Sept. 5. Gen. H. M. Chittenden, M. Am. Soc. C. E., chairman; Mr. Robert Bridges, Secretary, and Mr. C. E. Remsberg are the three commissioners.

Mr. Winslow H. Herschel, M. Am. Soc. M. E., of New York City, has been appointed Assistant Professor of Mechanical Engineering at the University of Maine. Prof. Herschel is a graduate of Lawrence Scientific School, Harvard University, and is a son of Mr. Clemens Herschel, M. Am. Soc. C. E., of New York City, with whom he has been associated in business. Mr. C. H. Lekberg, formerly with the Crompton & Knowles Loom Works, Worcester, Mass., has been appointed Instructor in Mechanical Engineering at the same institution.

Mr. Robert E. Horton, M. Am. Soc. C. E., has resigned as Resident Engineer, Bureau of Hydraulics, New York State Barge Canal, in order to devote his entire time to private practice. Mr. Horton was engaged by the New York State Engineer's Department in 1906 to take charge of special hydraulic investigations in conjunction with the design and construction of the Barge Canal, the broader hydraulic features of which are now substantially completed. He also had charge of the preparation of the technical defense by the State in connection with water power and other

water right claims. Mr. Horton has been retained by the State in a consulting capacity on pending water power claims. He will make his headquarters at 57 North Pine Ave., Albany, N. Y.

Mr. H. R. Safford, M. Am. Soc. C. E., of the Edgar Allen American Manganese Steel Co., Chicago, Ill., and formerly Chief Engineer of Maintenance-of-Way of the Illinois Central R. R., has been appointed Chief Engineer of the Grand Trunk Ry., with headquarters at Montreal, Que. Mr. Safford is a graduate of Purdue University, class of 1895, and entered the railway service as a rodman on the Illinois Central R. R.

Mr. Howard G. Kelley, M. Am. Soc. C. E., formerly Chief Engineer of the Grand Trunk Ry., has been made Vice-President in charge of construction, transportation and maintenance of the same railway. Mr. Kelley is a native of Philadelphia, Pa., and graduated from the Polytechnic College of Pennsylvania. He entered railway work in 1881 as an assistant engineer on the Northern Pacific Ry. He has been Chief Engineer of the St. Louis Southwestern, Minneapolis & St. Louis and Iowa Central Rys. He was President of the American Railway Engineering and Maintenance of Way Association in 1905, and is one of the councillors of the Canadian Society of Civil Engineers.

Obituary.

George Webber, one of the earliest elevator manufacturers of Newark, N. J., died on Oct. 5, at Boonton, N. J. He was 88 years old.

Prof. John Bascom, formerly President of the University of Wisconsin, and more recently Professor of Political Economy at Williams College, Williamstown, Mass., died on Oct. 3, aged 84 years.

Charles H. Pieper, City Engineer of San Jose, Cal., died from a cancer on Oct, 1. He was employed for a number of years with the Santa Fe Ry. System and for some time as a deputy in the office of the County Engineer. He was appointed City Engineer of San Jose in 1902.

Samuel A. Steel, a member of the one-time firm of Steel & Hall, contractors, of Pittsburgh, Pa., died from apoplexy in Wilkinsburg, Pa., on Oct. 5. The firm of Steel & Hall, which was dissolved some years ago, was contractor for the construction of several of Pittsburgh's largest industrial plants.

William H. Catlin, Superintendent of Highways of New York State, died in Albany, N. Y., on Oct. 5, from a stroke of paralysis. He was 70 years old and was appointed State Highway Superintendent by Governor Dix on July 17 last. He was a prominent real estate dealer and promoter, of Westchester County, previous to his appointment.

Archer Harman, President of the Guayaquil & Quito R. R. of Ecuador, died at Hot Springs, Va., on Oct. 9, as a result of injuries received on the previous day by a fall from his horse. His chief work was the building of this 300-mile South American railway, which had required practically all his time for the past 14 years. He was born in Staunton, Va. His father was an officer in the Confederate Army and was ruined financially by the war. The son entered early into railway contracting work, and at an early age obtained for himself a contract on the Colorado Midland R. R. In 1897 he went to Ecuador and succeeded in obtaining a concession for the construction of a railway. From that time he was continuously engaged either in Ecuador directing construction work, or in the United States and Europe obtaining money to complete the road. The road was completed about three years ago. Mr. Harman is survived by a widow and one daughter.

Engineering Societies.

COMING MEETINGS.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct 17-19. Annual convention at St. Louis, Mo. Secy., C. A. Lichty, C. & N. W. Ry., Chicago, Ill.

AMERICAN GAS INSTITUTE.
Oct. 18-20. Annual convention at St. Louis, Mo. Secy., A. B. Beadle, 29 West 39th St., New York City.

AMERICAN MINING CONGRESS.
Oct. 24-28. Annual session at Chicago, Ill. Secy., J. F. Callbreath, Denver, Colo.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 2-4. Annual meeting at Cincinnati, Ohio. Secy., Edward H. Reisner, 20 West 44th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 13-16. Annual meeting at Richmond, Va. Secy., Clinton R. Woodruff, 705 North American Bldg., Philadelphia, Pa.

AMERICAN ROADBUILDERS' ASSOCIATION.
Nov. 14-17. Annual convention at Rochester, N. Y. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN RAILWAY ASSOCIATION.
Nov. 15. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 75 Church St., New York City.

NATIONAL FOUNDERS' ASSOCIATION.
Nov. 15-16. Annual convention at New York City. Secy., F. W. Hutchings, 915 Hammond Bldg., Detroit, Mich.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16-17. Annual meeting at New York City. Acting Secy., D. H. Cox, 29 West 39th St., New York City.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 17-18. Annual meeting at Canton, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NEW JERSEY SANITARY ASSOCIATION.
Nov. 24-25. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Dec. 4-9. Annual meeting at Havana, Cuba. Secy., Wm. C. Woodward, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual convention at New York City. Secy., Calvin W. Rice, 29 West 39th St., New York City.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 11-13. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 12-14. Annual convention at Washington, D. C. Secy., Glenn Brown, the Octagon, Washington, D. C.

Cleveland Engineering Society.

At the meeting of Oct. 10, Mr. E. P. Roberts presented a paper entitled "Profitable Sharing Versus Profit Sharing."

Engineers' Club of St. Louis.

At the regular meeting of Oct. 4, Mr. Charles W. Martin, Engineer in the bridge division of the St. Louis street department, presented an illustrated paper on "Methods of Reinforced-Concrete Design."

Society of Engineers of Eastern New York.

A party of about 200 civil engineers, chiefly from Albany, Troy and Schenectady, made a trip Oct. 7 from Albany to the Ashokan Dam of the New York water-supply system.

New York Railroad Club.

Nominations of officers to be elected Nov. 17 have been made by the regular nominating committee, as follows: President, Frank Hedley; Vice-Presidents, W. J. Harahan, E. Chamberlin and Geo. W. Wildin; Treasurer, R. M. Dixon.

National Electric Light Association.

A new section was recently organized at Milwaukee, Wis., and will be known as the Milwaukee Electric Railway & Light Co. section. Officers have been elected as follows: President, O. M. Rau; Vice-President, A. H. Sikes; Secretary, Geo. C. Post; Treasurer, Frank J. Boehn.

American Society of Civil Engineers.

The Colorado Association of members of this society at its regular meeting in Denver, Colo., Oct. 14, will discuss a paper entitled "Economic Canal Location in Uniform Countries," by Lyman E. Bishop, which was published in the August "Proceedings." The discussion will be opened by Prof. C. C. Williams, of the University of Colorado.

American Society of Mechanical Engineers.

At the meeting held in the Engineering Societies' Bldg., New York City, on Monday evening, Oct. 9, a paper on the subject of factory construction and arrangement was presented by Mr. L. P. Alford and Mr. H. C. Farrell. The date of this meeting was arranged to permit the attendance of members of the National Machine Tool Builders' Association.

American Society of Engineering Contractors.

In our issue of Oct. 5 the report of the lecture by Mr. Myron H. Lewis on "Waterproofing As a Means of Insurance," was in error in stating that Mr. Lewis contended that the use of special waterproofing compounds seldom accomplished the desired result of making the concrete watertight. What Mr. Lewis really stated was that concrete was seldom made watertight without the addition of a special waterproofing compound.

Master Boiler Makers' Association.

This is the new name of what was formerly the International Master Boiler Makers' Association. The officers for 1911-12 are as follows: President, Geo. W. Bennett, Albany, N. Y.; Vice-Presidents, J. W. Kelly, Oak Park, Ill.; M. O'Connor, Missouri Valley, Iowa; T. W. Low, Winnipeg, Man.; James T. Johnston, Los Angeles, Cal., and Andrew Green, Indianapolis, Ind.; Treasurer, Frank Gray, Bloomington, Ill. The Secretary is Mr. Harry D. Vought, 95 Liberty St., New York City.

Society of Automobile Engineers.

The meeting of the division on wheel dimensions and fastenings for tires of the Standards Committee was held in New York City Oct. 5 in joint session with the representatives of leading tire manufacturers.

The first subject taken up was the matter of a standard bolt-hole circle for the flange type of solid tires. It was the sense of the meeting that the Standards Committee be requested to recommend the adoption of ½-in. as the diameter of through bolts for all sizes of solid rubber tires for motor cars. It was further agreed that the diameter of the bolt-hole circle for 36-in. tires should be 28½ ins., with increase or decrease by even 2 ins. for larger or smaller tires. The number of bolts agreed upon was 8, 12 or 24, according to the requirements, for tires up to and including 36 ins. in diameter; 10, 15 or 30 for tires between 36 ins. and 42 ins. in diameter; 12, 18 or 36 for tires from 42 to 48-in. diameter, and 14, 21 or 42 for 48 to 54-in. tires. All bolts should be equally spaced.

Mr. Arthur Ryan, of New York City, addressed the meeting on the subject of standardization and grading of woods for artillery wheels for automobiles, and Mr. W. P. Kennedy presented a paper entitled "Seasoning of Timber for Wheels." It was decided that further data should be collected on this subject.

At the conclusion of the meeting Mr. William E. Metzger, President of the National Association of Automobile Manufacturers, made an address in which he outlined the work of the Society of Automobile Engineers in the standardization of wheel sizes for motor trucks. The work had been done by specifying the diameter of a permanent metal band, ¼ to ⅜-in. thick, to which the tire must be applied. This insured that the truck wheel would have the same diameter for a given tire diameter, no matter what the width of the tire. The metal band, whose diameter was specified, was never to be removed from the wheel, and it served as a foundation to which must be attached all special metal equipment or fastenings necessary with the different makes of solid tires. The interchangeability of tires thus brought about was highly desirable.

American Society for Testing Materials.

The organization meeting of Committee C-4 on Standard Specifications for Drain Tile was held Sept. 28 in Chicago, Ill. Officers were elected as follows: Permanent Chairman, Prof. A. Marston, Iowa State College; Vice-Chairman, Prof. A. N. Talbot, University of Illinois; Secretary, Prof. J. T. Stewart, University of Minnesota. The committee is made up of eight members representing the consuming interests, four members representing the cement tile manufacturers and four members representing clay tile manufacturers. Besides the three officers named, the members representing the consuming interests are Prof. Geo. B. Chatburn, of the University of Nebraska; Mr. Rudolph Hering, of New York City; Mr. Mont Schuyler, of St. Louis, Mo.; Prof. F. E. Turneaure, of the University of Wisconsin, and Dr. Samuel Fortier, of Washington, D. C.

Mr. Rudolph Hering and Prof. F. E. Turneaure were not present at this meeting, and three other members were represented only by proxies.

Five sub-committees were organized to take up the following subjects: (1) tests; (2) durability; (3) construction and specifications; (4) data of manufacture of clay tile; (5) data of manufacture of cement tile. Meetings of these sub-committees were held on the following day, Sept. 29. The Committee on Tests proceeded to outline a series of tests to be conducted at each of three laboratories for comparison of the two principal methods (one with distributed and one with concentrated load) which have been proposed for standard tests. About 700 tests are to be made at each laboratory. Carefully selected cement and clay pipe will be used, of uniform quality and of three different sizes. The laboratories chosen for these tests are those of the Iowa Engineering Experiment Station at Ames, Iowa; the City Testing Laboratory at St. Louis, Mo., and the Laboratory of the University of Illinois, at Urbana. In addition, it was decided to have repeated at these laboratories, if possible, the investigation of actual pressures on drain tile in ditches reported by Prof. Marston as being already in progress at the Iowa Engineering Experiment Station.

It was voted to attempt the preparation of at least tentative specifications to be presented at the next meeting of the American Society for Testing Materials in 1912.

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